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Project 2.61
Rocket Determination of Activity Distribution Within the Stabilized Cloud

Pacific Proving Grounds
May — July 1956

Headquarters Field Command
Defense Atomic Support Agency
Sandia Base, Albuquerque, New Mexico

April 28, 1960

NOTICE

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FOREWORD

This report has had classified material removed in order to make the information available on an unclassified, open publication basis, to any interested parties. This effort to declassify this report has been accomplished specifically to support the Department of Defense Nuclear Test Personnel Review (NTPR) Program. The objective is to facilitate studies of the low levels of radiation received by some individuals during the atmospheric nuclear test program by making as much information as possible available to all interested parties.

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FOREWORD

This report presents the final results of one of the projects participating in the military-effect programs of Operation Redwing. Overall information about this and the other military-effect projects can be obtained from WT-1344, the "Summary Report of the Commander, Task Unit 3." This technical summary includes: (1) tables listing each detonation with its yield, type, environment, meteorological conditions, etc.; (2) maps showing shot locations; (3) discussions of results by programs; (4) summaries of objectives, procedures, results, etc., for all projects; and (5) a listing of project reports for the military-effect programs.

ABSTRACT

Forty especially developed atmospheric-sounding projectiles (ASP) were fired through the clouds resulting from Shots Cherokee, Zuni, Navajo, and Tewa to proof test a system for measuring gamma intensities within the clouds and to explore the spatial distribution of gamma activity within the stem and cloud resulting from the detonation of a nuclear device having a yield in the megaton range. Radiation intensity information was successfully telemetered out of the radioactive clouds by the ASP rockets and recorded on magnetic tape. Radiation intensities as high as 3 by 10^4 r/hr were encountered within the cloud; intensities at the one measured point in the stem were negligible compared to the peak activity within the cloud. Contamination of rocket surfaces by radioactivity from the cloud did not appear to be of consequence. Total activities in the clouds computed from rocket data agreed in order of magnitude with activities derived from theoretical considerations.

PREFACE

This project was undertaken as a joint effort by members of the U.S. Naval Radiological Defense Laboratory (USNRDL) and Cooper Development Corporation of Monrovia, California. The responsibilities of Cooper Development Corporation were defined in Bureau of Ships Contract, No. NObs 72000. These included responsibilities for the design, development, and testing of the rockets used in the project, firing of the rockets in the field, recording of data from rockets fired in the field, and reduction of data. NRDL furnished field personnel, including a project officer, and was responsible for interpreting the reduced data as presented by the contractor.

The project officer extends his thanks and appreciation to those individuals and groups who through their cooperation and assistance contributed materially to the successful completion of the project. Their specific contributions are cited as follows: H. R. Wasson of USNRDL, who offered technical advice and assistance in the design and testing of the radiation transducer; Lieutenant (jg) M. H. Eklund of USNRDL, who prepared the general specifications for the radiation transducer, offered technical advice and performed the field calibration of the instruments; Captain and crew of the USS Knudson, APD-101, who assisted in the installation and operation of the shipboard telemetering receiving station; and Commanding Officer and men of Detachment A, Mobile Construction Battalion 5, who assisted in the installation of the rocket launching station and the Site Nan receiving station and performed the technical survey work.

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Chapter 1
INTRODUCTION

1.1 OBJECTIVES

The specific objectives of Project 2.61 were to: (1) proof test a system using rocket-borne detection units with telemetering transmitters to explore the spatial distribution of radioactivity in the stem and cloud resulting from a nuclear detonation; (2) measure gamma intensities along several continuous known trajectories passing through the stem and cloud at 7 and 15 minutes after detonation; and (3) estimate the extent to which the rocket became contaminated as it passed through the stem or cloud.

1.2 BACKGROUND AND THEORY

Although various mathematical models for the fallout process have been presented (Reference 1), gross differences exist among the assumptions as to spatial distribution of radioactive emitters in the cloud and stem. Determination of the distribution which actually exists is essential to the development of a correct model and the eventual realistic predictions of fallout patterns. Without such knowledge there would be continuing uncertainties as to the spatial positions of active particles prior to fall, resulting in unreliable predictions of the spread and extent of activity. Besides being essential to the development of fallout theory, a knowledge of the distribution of radioactivity in the cloud and stem at early times may be important for interception, countermeasures, and long-range-detection studies.

Construction of an effective fallout model requires knowledge of the size, activity, and spatial distribution of radioactive particles in the stem and cloud. Of these parameters, particle size distribution and related activity were determined from particles collected as fallout at the surface of the earth by Projects 2.63 and 2.65. If, in addition, measurements of gamma intensities in the stem and cloud are made, gross distribution of active particles in the stem and cloud may be inferred. Restrictions due to time and equipment available before the operation precluded measurement by this project of any parameter except gamma activity as a function of time and position.

Measurements of radiation fields existing in clouds resulting from detonations of devices in the kiloton range have been made previously. The first measurement of cloud-radiation fields was made during Operation Greenhouse by the use of drone aircraft. These measurements were made in the stems of clouds resulting from explosions whose yields ranged from

Fields of about 10^4 r/hr were observed at 3 to 5 minutes after detonation and of about 350 r/hr at 30 minutes after detonation (Reference 2). During Operation Upshot-Knothole, cannisters and drone aircraft operated in the mushroom tops resulting from 11 to 26 kt explosions. Fields of about 10^4 r/hr existed at 2 to 6 minutes after detonation (Reference 3).

During Operation Redwing, aircraft were flown through the stem and lower portion of six clouds resulting from detonations in the megaton range. Reference 4 gives as the average dose rates encountered when corrected to 100 percent-fission yield:

$$\bar{D} = 1.0 \times 10^5 \, t^{-1.7} \tag{1.1}$$

Where: D = average dose rate, r/hr
t = time after detonation, minutes

This equation yields 3,700 r/hr and 1,000 r/hr as the average dose rate to be expected at 7 minutes and 15 minutes from a 100 percent-fission yield device. A vehicle, capable of carrying a radiation detector and telemetering equipment to at least the top of the highest cloud expected, was required to explore the spatial distribution of gamma activity in clouds resulting from multimegaton detonations. It was desirable that the vehicle be able to pass well out of the top or side of the cloud, so that an indication of the contamination of the vehicle could be obtained. Because of the altitudes involved and turbulent conditions existing at early times, manned or unmanned aircraft could not be used to measure activity within the higher regions of the cloud resulting from a megaton range device. The above, along with considerations of expense and logistic problems, indicated that a single-stage, rocket-propelled ballistic missile would serve best to carry the detector and telemetering equipment.

To serve as a basis of comparison for the activity distributions as determined by the rocket flights, theoretical estimates were prepared of the number of photons per second present at 7

TABLE 1.1 THEORETICAL ESTIMATES OF CLOUD ACTIVITY

Time	Contributor	Activity, photons/sec		
		Cherokee	Zuni	Navajo
min				
7	FP	29.3×10^{22}	7.69×10^{22}	3.69×10^{22}
	U^{239}	4.7×10^{22}	1.07×10^{22}	0.13×10^{22}
15	FP	14.8×10^{22}	3.92×10^{22}	1.89×10^{22}
	U^{239}	3.7×10^{22}	0.84×10^{22}	0.12×10^{22}

and 15 minutes after detonation (times at which the rocket measurements were made). The contribution to the total activity of the device components only was considered. The fission product activity, based on the slow neutron fission of U^{235}, at 7 and 15 minutes was found to be

respectively (Reference 5). At these early times, the induced activity contribution of U^{239} was considered. Other induced activities with gamma energies in the range that can be measured by the rocket transducer could possibly add around 5 percent to the activities tabulated in Table 1.1 depending upon materials used in the construction of the device and nearby structures. The other induced nuclides of Np^{239}, U^{240}, Np^{240} and U^{237} represented less than 1 percent of the activity due to the fission products. For capture-to-fission ratio of 1.0, the calculated activities of U^{239} at 7 and 15 minutes were 4.0 d/s/10^4 fissions and 3.2 d/s/10^4 fissions, respectively. Applying directly the capture-to-fission ratios 0.500, 0.427 and 0.125 as determined from actual samples obtained during Shots Cherokee, Zuni, and Navajo, the contribution of U^{239} to the total activity for the various events was then determined. The use of theoretical estimates (personal communication from C. F. Miller and N. E. Ballou, USNRDL) for the number of photons per disintegration for the fission products, 1.19, and U^{239}, 0.83, and the number of fissions per kiloton of fission yield, 1.45×10^{23}, together with the d/s/10^4 fissions values for the fission products and U^{239} then yielded the activity per event in photons/second at specified times. The data obtained are presented in Table 1.1.

Chapter 2
PROCEDURE

2.1 PARTICIPATION

The project participated in Shots Cherokee, Zuni, and Navajo (air, land and water detonations, respectively) and to a limited extent in Shot Tewa (a surface detonation over shallow water). The original intent of the project was to participate in Shots Cherokee, Zuni, and Navajo only. However, since there were four rockets (spare units) remaining at the conclusion of the Navajo event, the decision was made in the field to fire them during Shot Tewa. Forty rockets and radiation transducers with accompanying telemetering gear were used.

Thirty-six rockets were fired for Shots Cherokee, Zuni, and Navajo. Twelve rockets were fired in two salvos of six during these events. The first salvo was fired at 7 minutes and the second at 15 minutes after detonation with 2-second intervals between rockets of each salvo. The four additional rockets were fired during Shot Tewa at 7 minutes after detonation with 10-second intervals between them. For Shots Cherokee, Zuni, Navajo (second salvo), and Tewa, the rockets of a single salvo had different trajectories in a single vertical plane. For Shot Navajo, the six rockets of the first salvo were fired at the same quadrant elevations but at different azimuthal angles. Trajectories were determined before the detonations on the basis of predicted winds. Some rockets were fired so as to pass through the cloud or stem into a radiation-free area while their signals were still being received, so that the contamination of the rocket could be estimated.

2.2 INSTRUMENTATION

Fifty units of an especially developed rocket were produced for this operation. The radiation transducers, likewise, were especially developed. Commercial equipment served as the transmitting and receiving units.

2.2.1 Rockets. Prior to the acceptance of the proposal for this project, there was no single-stage, solid-fuel rocket that could attain an altitude of 100,000 feet when launched from sea level. Design, fabrication, and testing of the rocket was accomplished by Cooper Development Corporation, who also had the responsibility for launching the rockets and recording their data in the field. The result was a $6\frac{1}{2}$-inch diameter by approximately 12-foot-long rocket capable of attaining a maximum altitude of about 200,000 feet or a maximum range of about 230,000 feet. The radiation detector and telemetering transmitter were located in the ogive (head assembly). Figure 2.1 is a schematic drawing of the rocket.

This rocket, the atmospheric-sounding projectile (ASP), was a ground-launched ballistic missile using a solid fuel. The single-grain propellant consisted of a stabilized ammonium perchlorate oxidizer with a Thiokol base. The single-stage motor had a total impulse of 31,000 lb-sec and a burning time of 5.8 seconds. The burnout velocity of the rocket was approximately 5,400 ft/sec. The prelaunch weight was 245 pounds with a burnout weight of 93 pounds.

Rockets were launched from a simple rail-type launcher employing a zero-tipoff system. Figure 2.2 shows one set of rockets on their launchers at Site How. In this zero-tipoff launching system, as a rocket moves forward, it is supported on the rail by two launching shoes. As the forward shoe leaves the front of the rail, it drops free of the rocket, and the after shoe is sheared off by a block on the launcher rail, permitting the rocket to continue to move parallel to the rail without tipoff error.

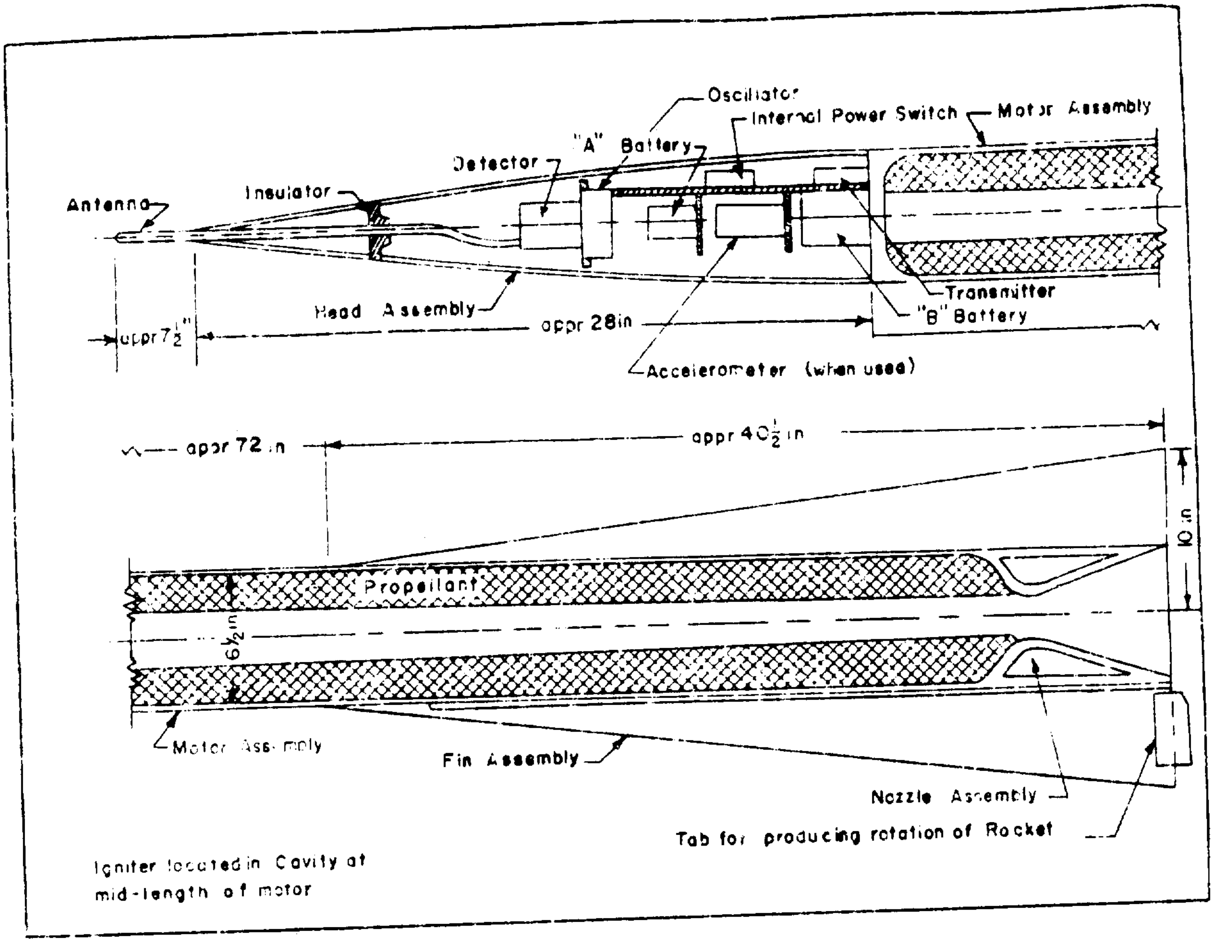

Figure 2.1 Cut-away view of atmospheric sounding projectile (ASP).

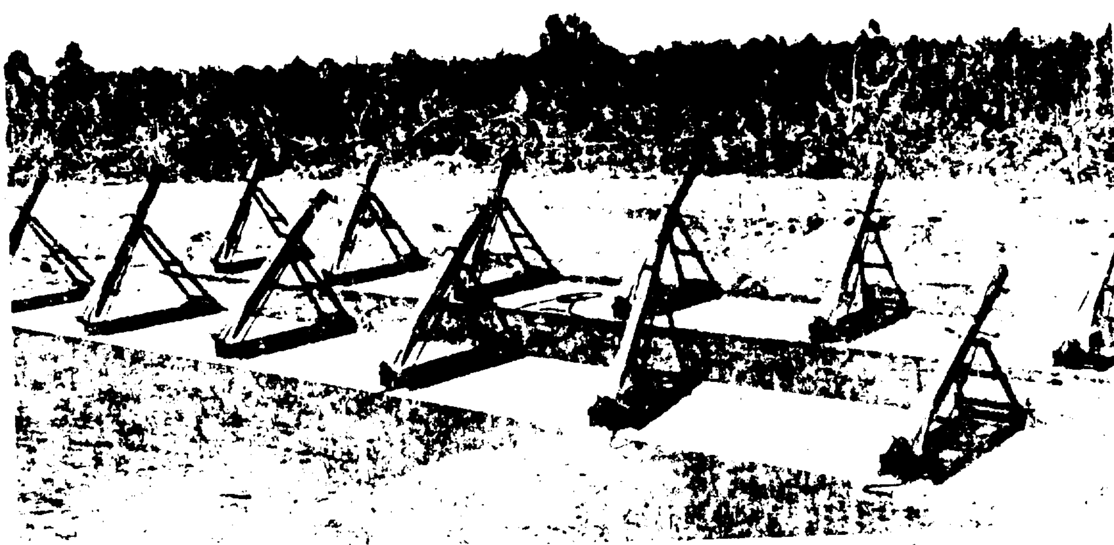

Figure 2.2 One set of rockets and their launchers (concrete pads are 100 feet long by 12 feet wide).

The rockets were caged in position on the launchers during all events until the shock wave passed. In Figure 2.2, all rockets were caged except the one in the lower right-hand corner, on which the caging clamps stand open and are visible just above the supporting A-frame. The cages were closed with explosive bolts, whose detonation by the timer just prior to launching uncaged the rockets.

Nine rockets were expended making preoperational flight tests and obtaining trajectory information. Figure 2.3 is a plot of range versus altitude for various quadrant elevations of launching of the rockets from sea level in a standard (National Advisory Council for Aeronautics) atmosphere. Time marks are indicated on the trajectories. Trajectories were calculated from information gathered at test firings at the Naval Air Missile Test Center, Point Mugu, California, and at White Sands Proving Grounds, New Mexico. Four rounds were fired at Point Mugu and five at White Sands. Of these, eight were fired at a quadrant elevation of $\frac{1}{2}$ radian (28.6 degrees), and one, at an elevation of $1\frac{1}{2}$ radians (85.9 degrees). Rockets were tracked by phototheodolites, skin-tracking radar, and velocimeters (doppler radar). The velocimeter and phototheodolites were able to track the rockets to burnout, whereas radar tracked them to impact.

One test rocket was fired in the field in conjunction with the Shot Cherokee dry run to check out the complete system, including the Site How launching station and the Site Nan and USS Knudson receiving stations. The USS Knudson was stationed at a point which was at the same general bearing and range relative to the test rocket trajectory as the planned trajectories for Shot Cherokee. Good signal strength was received at both receiving stations.

2.2.2 Radiation Transducers. The transducer (Figure 2.4), composed of the ionization chamber and the blocking oscillator circuit, was assembled as a single compact unit and mounted in the forward part of the ogive of each rocket. The ion chamber-electrometer devices were capable of measuring gamma radiation at dose rates from at least 10,000 r/hr to less than 10 r/nr with an energy response of 0.1 to 2.0 Mev. The electrometer circuit was designed to operate in a cyclic mode to produce pulses directly proportional to the dose rate. The pulses modulated the telemetering FM transmitter (Ralph M. Parsons Company Model 7501), which supplied 2 or 3 watts to the antenna (a $7\frac{1}{2}$-inch spike protruding from the nose of the rocket).

The ion chamber had the following characteristics:

Type of construction - Parallel-plate guard ringed
Gas and pressure - Pure Argon, 15 atmospheres
Collecting volume - Nominal 100 cc
Maximum radiation rate - 10,000 r/hr
Current output - Nominal 10^{-10} amps/r/hr
High voltage electrode voltage - 180 volts
Number of plates - 4 HV, 3 collecting
Collecting-to-HV electrode capacitance - 40 to 50 $\mu\mu f$
Plate spacing - 0.48 cm
Beta response - None

The energy response of the chamber alone was not specified, as it was measured as a function of direction over the entire 4π solid angle as installed in the rocket.

The electrometer circuit was the simple blocking oscillator shown in Figure 2.4. Its operation may be briefly traced as follows. If a pulse has just occurred, the grid of the electrometer tube is at a negative potential of 10 to 15 volts with respect to ground and completely cuts off the tube. Ionization caused by gamma radiation incident on the chamber discharges the chamber capacitance; since the ion chamber is completely saturated, the discharge is linear with respect to time. As the grid voltage rises, the tube gradually reaches a critical trigger value, at which time regeneration occurs through the chamber capacitance. The chamber is recharged by grid current as the pulse occurs; when the pulse falls, the grid diode action ceases and the grid resets to the negative cut-off potential. Each pulse out represents a certain increment of dose, so the repetition rate of the pulses is proportional to the dose rate. The nominal pulse-rate of the circuit was 0.2 pps/r/hr, so the upper pulse-rate at 10,000 r/hr was 2 kc and the incremen-

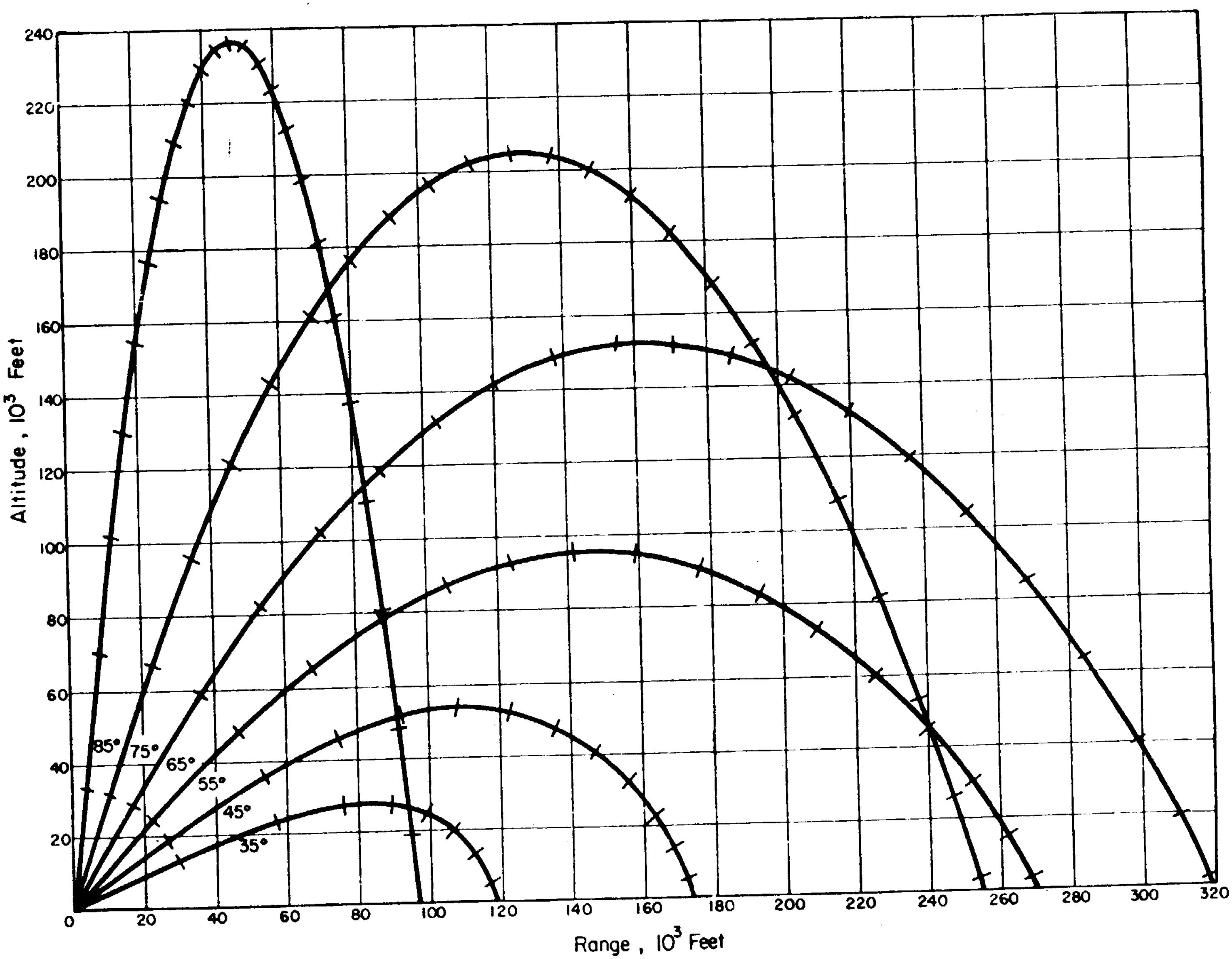

Figure 2.3 Trajectories of ASP rockets (mark on trajectories in 10-second intervals).

tal dose per pulse was nominally 1.4 mr. The upper radiation dose was determined by chamber saturation characteristics; dose rates above 10,000 r/hr may be measured with reduced accuracy by applying appropriate correction factors to the data. The lower limit is set by the vacuum tube grid current and varies somewhat from unit to unit.

The relative polar response of the chamber was determined by using gamma or X-rays of various energies. These data were obtained by operating chambers inside ogives (the forward

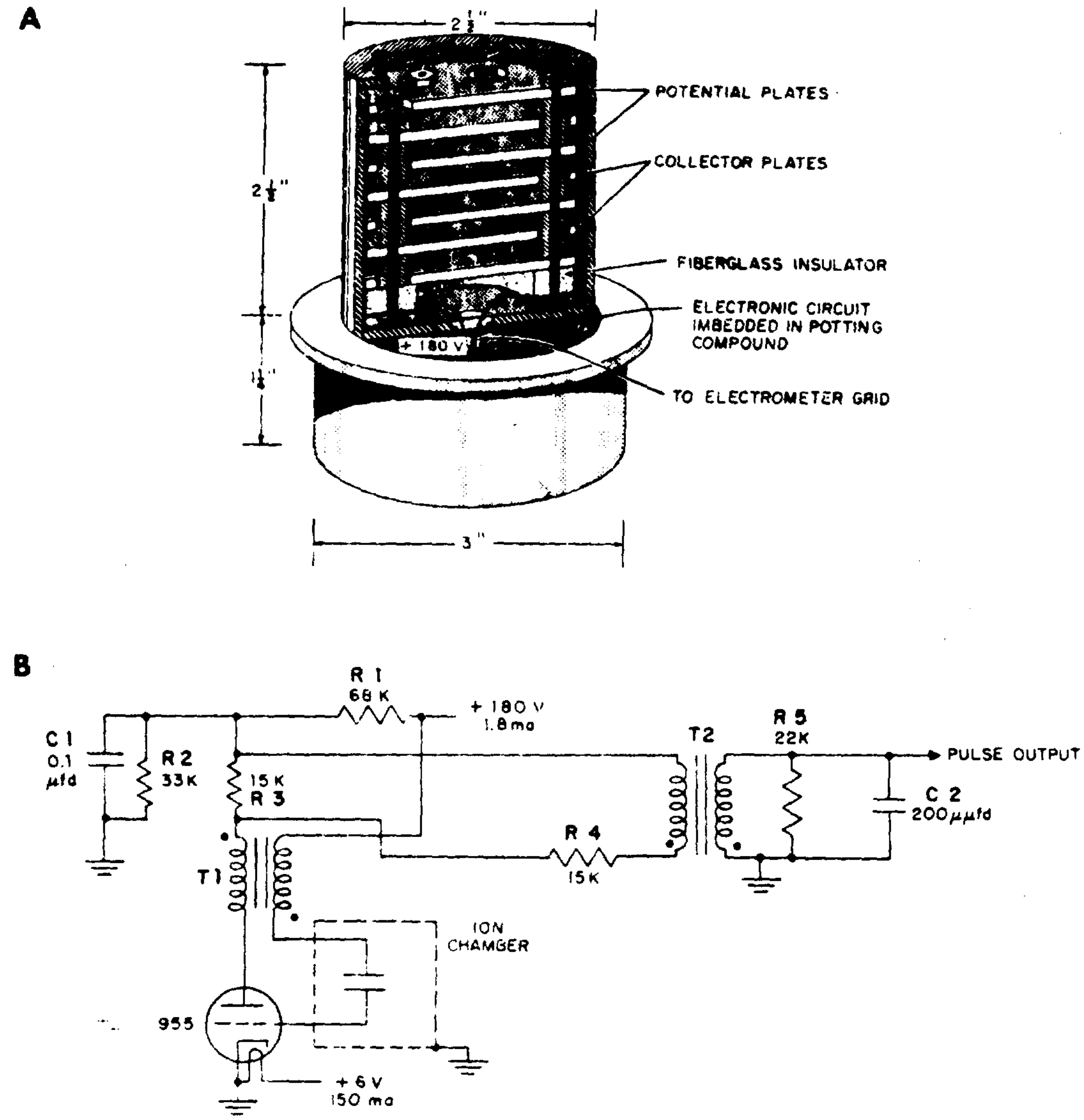

Figure 2.4 Radiation transducer schematic.

element of the rocket containing telemetering equipment) with associated equipment and exposing them to gamma and X-rays of various energies at different polar angles. As shown in Figure 2.5, the low energy response was relatively high along the normal to the vehicle axis. This response was considered desirable to compensate for low energy attenuation in other directions. Integration of the 1.3 Mev curve indicated that the integrated response was 85 percent of that due to a point source producing the same field but located on a line passing through the center of the chamber and normal to the axis of the chamber. The integrated response over the 4π solid angle was relatively flat as shown in Figure 2.6. From this curve it can be seen that the response of the chamber was independent of energy within ± 10 percent from 90 to 2,000 kev.

The radiation transducers for the rocket flights showed a range of sensitivities of 0.17 to 0.39 pulse/sec/r/hr when calibrated with a 4-curie point source of Co^{60}. As noted above, the sensitivity was reduced by 15 percent when the transducers were operated inside the rocket ogive in a uniformly distributed radioactive field.

2.2.3 Launching Site. A launching revetment was constructed on Site How (10 to 18 miles from the shot points). The revetment consisted of two concrete launching pads, each 100 feet by 12 feet; an embankment to protect the launchers from possible water waves; and an instrument shelter.

Firing of the rockets was controlled by a sequence timer located in the instrument shelter. The timer was armed by a minus 1-second signal provided by an Edgerton, Germeshausen and

TABLE 2.1 RANGE AND BEARINGS OF SHOT POINTS FROM RECEIVING STATIONS AND LAUNCHING REVETMENT

Shot		Cherokee *	Zuni	Navajo	Tewa
Site How Launching Revetment	Range	92,300 †	76,800 †	55,600 †	73,000 †
	Bearing	285 ‡	232 ‡	283 ‡	283 ‡
Site Nan Receiving Station	Range	116,000 †	70,800 †	81,000 †	97,100 †
	Bearing	302 ‡	261 ‡	308 ‡	304 ‡
APD 101 Receiving Station	Range	195,000 †	165,000 †	160,000 †	200,000 †
	Bearing	330 ‡	280 ‡	315 ‡	310 ‡

* Planned Ground Zero.
† Range, feet.
‡ Bearing, degrees.

Grier (EG&G) timing relay. Two blue boxes were arranged so that the timer would also start if one or both of the boxes were triggered by the bomb light. The timer started the local power generators after the blast wave had passed. (The local power generators were left running when the shelter was secured for Shot Cherokee and the shock wave stopped them; therefore, the generators were started by the sequence timer after passage of the shock wave for subsequent shots.) turned on the long-wave transmitter, started the rocket telemeters, uncaged the rockets, ignited the rocket flares, and fired the rockets. Power for all but the long-wave transmitter was supplied by batteries.

The long-wave transmitter, a BC-610 AM transmitter operated at 2.545 Mc, was located at the launching revetment and relayed the launching times of the rockets to telemetering receiving stations.

2.2.4 Receiving Stations. Duplicate receiving stations were set up at Site Nan and aboard the USS Knudson (APD-101). Figure 2.7 shows the position of the receiving stations. Table 2.1 gives the range and bearing of the various ground zero locations from the launching revetment at Site How, the shipboard receiving station, and the Site Nan receiving station.

The two receiving stations were similar except that the one at Site Nan was unmanned at shot time and was equipped with automatic timing equipment to operate the recording devices. The basic equipment of the stations consisted of six Raymond Rosen 842-C FM telemetering receivers, a R-390/Urr AM receiver tuned to 2.545 Mc, and an Ampex Model S 3530 seven-channel tape recorder. Telemetering frequencies of 223, 224, 225, 226, 227, 228, and 239 Mc were assigned, giving six channels and one spare. The six signals from the rocket telemeters were detected and recorded on six of the channels. The launch signals from the BC-610 transmitter at the launching site were recorded on the seventh channel. In addition to the basic information

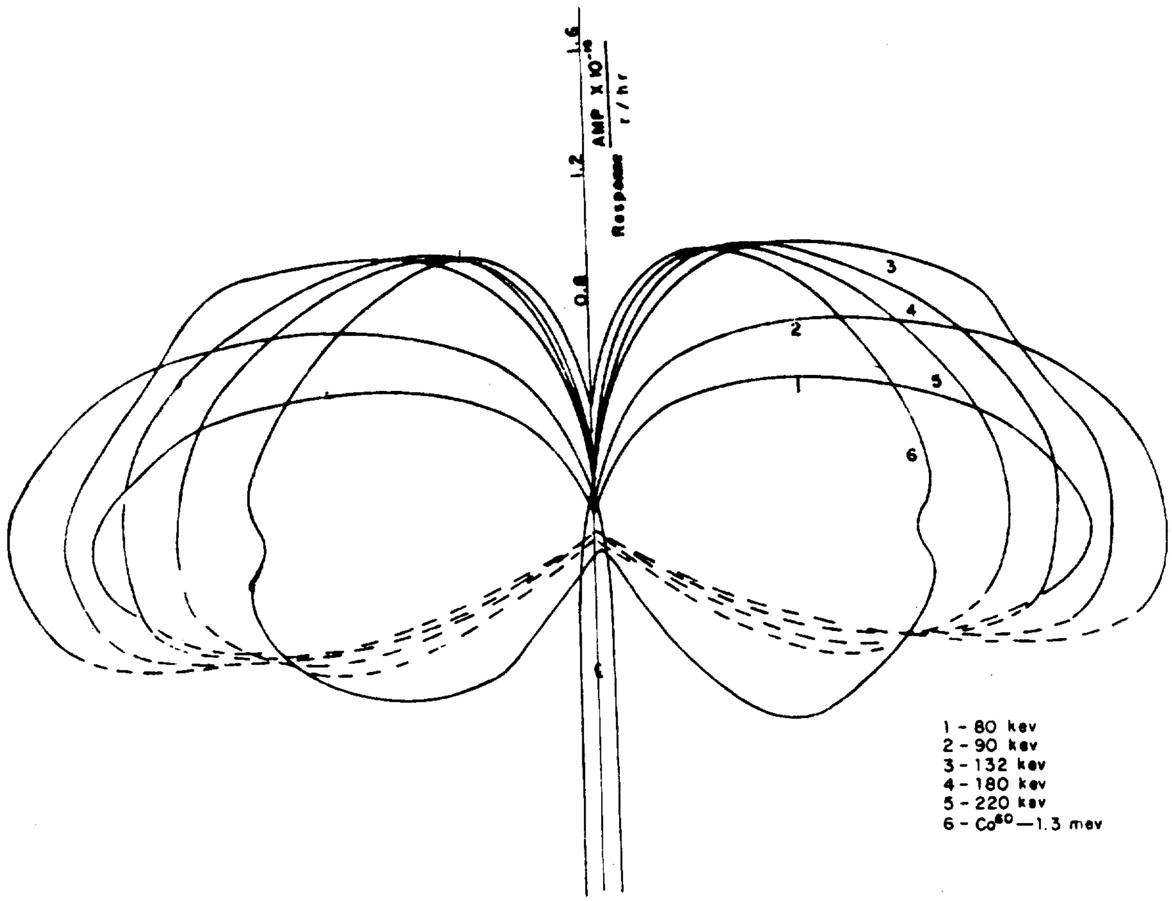

Figure 2.5 Energy and direction response of ASP radiation transducer.

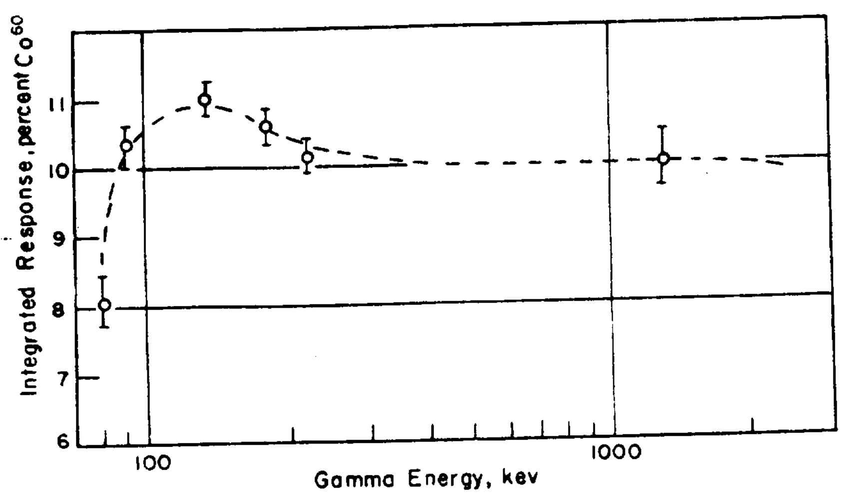

Figure 2.6 ASP radiation transducer energy dependence for uniformly distributed source.

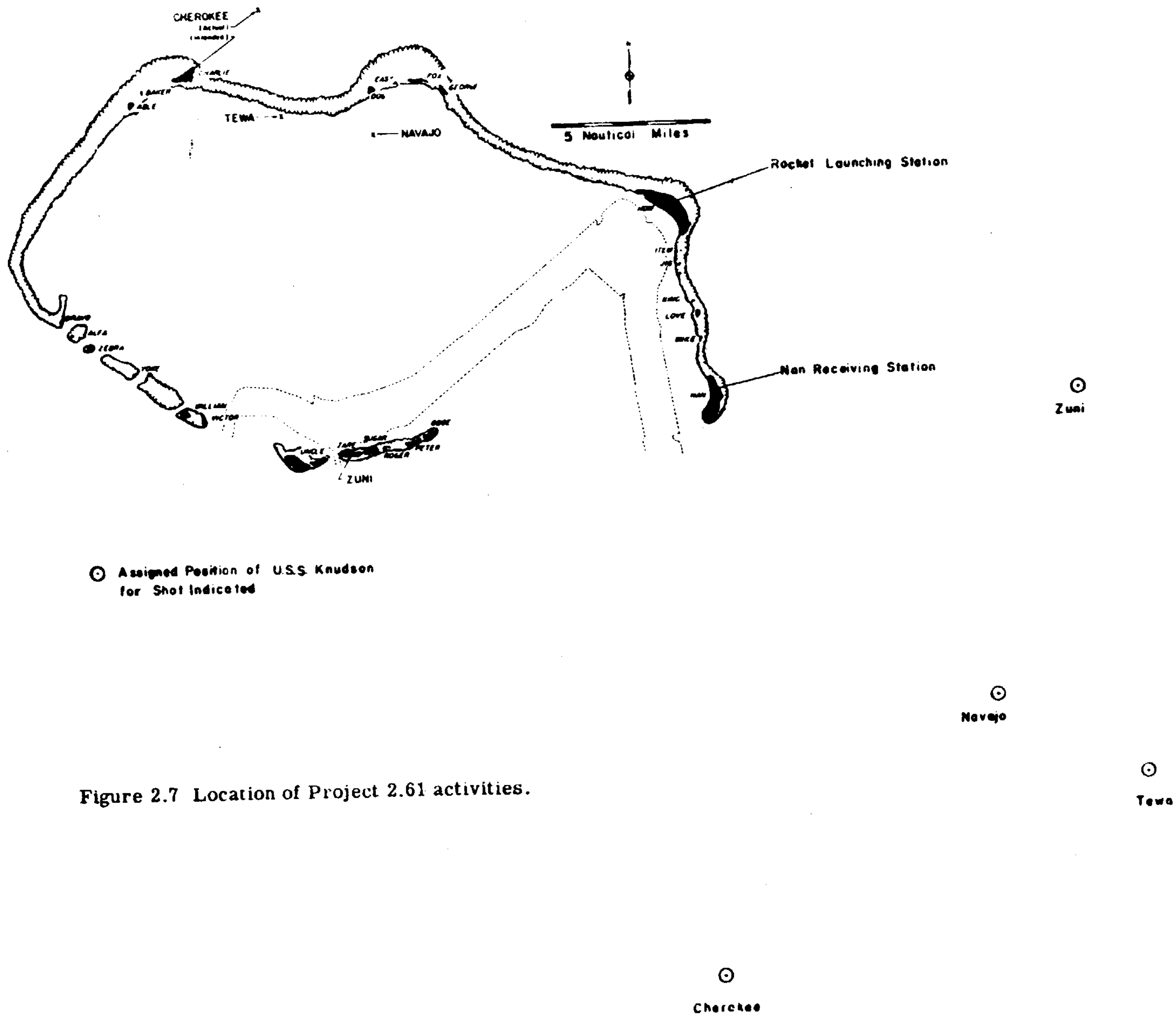

Figure 2.7 Location of Project 2.61 activities.

on radiation intensity, the strength of the carrier signal, as received at the shipboard station, was recorded on six channels of an oscillograph.

Automatic readout equipment at the shipboard station was intended to record the six channels of information simultaneously on a logarithmic scale as a function of time. However, the equipment failed prior to the first event, probably due to overheating of components. Repair in the field was impossible since the components were imbedded in potting compound.

2.3 DATA REQUIREMENTS

Data required to meet the objectives of the project consisted of general observations upon the working of the system and radiation intensity measurements as a function of rocket position. Supplementary data were also obtained on telemetering transmitter carrier field strength. The latter data were used as an aid in interpreting the primary data. Radiation intensity information was recorded on magnetic tape, while carrier field strength was recorded on oscillograph paper.

Magnetic tapes containing the primary information were processed by Cooper Development Corporation at Monrovia, California. Simultaneous readout of six channels of information on the magnetic tapes was accomplished utilizing a six-channel discriminator capable of sorting out data in the presence of a high noise background. With the information thus obtained together with field strength records from the shipboard station, the rocket transmitters were identified with specific channels at a given time. The reduced data were presented in the form of radiation-intensity readings as a function of time after launching.

Chapter 3
RESULTS

3.1 GENERAL PERFORMANCE OF THE SYSTEM

During Shot Cherokee all rockets fired and good (data, pulses could be heard well with no noise background) signal strength was received on all channels. The blast wave stopped two generators at the launching station, causing loss of the rocket-launch signals. However, data from later firings provided sufficient information for computing the launch times. In spite of relatively high radiation fields (3×10^4 r/hr) no serious attenuation of the telemetering signal was noted. There were no data on channels corresponding with rockets shot at the stem. It is probable that these projectiles missed the stem.

All rockets fired during Shot Zuni, and good signal strength was received on all channels. Radiation fields that were measured were lower than those encountered during Shot Cherokee. Channels corresponding to rockets aimed at the lowest elevations had no data on the carriers.

All Shot Navajo rockets fired, and good signal strength was received on 10 of the 12 channels. Radiation fields measured were lower than those previously encountered. Channels corresponding to rockets aimed at the stem indicated low activity there.

Four spare rockets were instrumented and prepared for launching during Shot Tewa. All fired, and good signal strength was received on three of the four channels. One transmitter failed shortly (about 5 seconds) after takeoff, and one transmitter was considerably off frequency. Accelerometers were used on two of the rockets. Useful radiological intensity information was received from only rocket (Round 3).

In all events, instability in the transmitter-receiver portion of the telemetering system caused receivers to pick up rocket transmitters other than those assigned; also, there were cases of receivers changing from one rocket transmitter to another during a particular salvo.

3.2 TELEMETERED INFORMATION

Tables 3.1, 3.2, 3.3, and 3.4 summarize launch conditions for Shots Cherokee, Zuni, Navajo, and Tewa. The column headed Azimuth gives the azimuthal settings of the launchers with respect to ground zero stations.

Figures 3.1 and 3.2 give roentgen intensity versus time information that is typical of the various shots. Tables 3.5 through 3.8 summarize all the information from telemetering channels upon which there were data for Shots Cherokee, Zuni, Navajo, and Tewa. These tables show only the information for the more reliable early portions of the trajectories, where the accuracy of the trajectory information was estimated by the contractor to be within ± 10 percent. In all cases zero time is the time of launch of the rocket. Sketches of the clouds with rocket trajectories are presented in Figures 4.2 through 4.6 in Chapter 4.

Rockets fired at the stem of the Shot Navajo cloud yielded no data although the rocket transmitters and transducers appeared to be operating normally.

Contamination of the rocket surfaces was not serious. Table 3.9 indicates in terms of percentages of peak readings the contamination of rockets for which the telemetered record was long enough for contamination determinations to be made. Four rockets had residual readings

TABLE 3.1 SUMMARY OF LAUNCH CONDITIONS FOR SHOT CHEROKEE

Rocket	Azimuth *	Quadrant Elevation	Launching Time
		degrees	min:sec
1A	GZ	36	H + 7:00
2A	GZ	43	H + 7:02
3A	GZ	53	H + 7:04
4A	GZ	65	H + 7:06
5A	GZ	75	H + 7:08
6A	GZ	85	H + 7:10
1B	GZ	35	H + 15:00
2B	GZ + 25 deg right	44	H + 15:02
3B	GZ + 25 deg right	55	H + 15:04
4B	GZ + 25 deg right	65	H + 15:06
5B	GZ + 25 deg right	75	H + 15:08
6B	GZ + 25 deg right	85	H + 15:10

* GZ is ground zero predicted for Shot Cherokee.

TABLE 3.2 SUMMARY OF LAUNCH CONDITIONS FOR SHOT ZUNI

Rocket	Azimuth	Quadrant Elevation	Launching Time
		degrees	min:sec
1A	GZ	31	H + 7:00
2A	GZ	35	H + 7:02
3A	GZ	45	H + 7:04
4A	GZ	55	H + 7:06
5A	GZ	65	H + 7:08
6A	GZ	85	H + 7:10
1B	GZ	31	H + 15:00
2B	GZ	45	H + 15:02
3B	GZ	55	H + 15:04
4B	GZ	65	H + 15:06
5B	GZ	75	H + 15:08
6B	GZ	85	H + 15:10

TABLE 3.3 SUMMARY OF LAUNCH CONDITIONS FOR SHOT NAVAJO

Rocket	Azimuth	Quadrant Elevation	Launching Time
		degrees	min:sec
1A	GZ + 3 deg left	35	H + 7:00
2A	GZ + 2 ½ deg right	35	H + 7:02
3A	GZ + 6 deg right	35	H + 7:04
4A	GZ + 9 ½ deg right	35	H + 7:06
5A	GZ + 15 deg right	35	H + 7:08
6A	GZ + 20 deg right	35	H + 7:10
1B	GZ + 20 deg right	55	H + 15:00
2B	GZ + 20 deg right	65	H + 15:02
3B	GZ + 20 deg right	85	H + 15:04
4B	GZ + 20 deg right	55	H + 15:06
5B	GZ + 20 deg right	65	H + 15:08
6B	GZ + 20 deg right	85	H + 15:10

TABLE 3.4 SUMMARY OF LAUNCH CONDITIONS FOR SHOT TEWA

Rocket	Azimuth	Quadrant Elevation	Launching Time
		degrees	min:sec
1A *	GZ	50	H + 7:00
2A	GZ	65	H + 7:10
3A	GZ	75	H + 7:20
4A *	GZ	85	H + 7:30

* Accelerometer rounds.

TABLE 3.5 SUMMARY OF INFORMATION TELEMETERED FROM VARIOUS ROCKETS DURING SHOT CHEROKEE

Time After Launch	Radiation Intensity, r/hr							
	Rocket 2A	Rocket 3A	Rocket 4A	Rocket 5A	Rocket 6A	Rocket 2B	Rocket 4B	Rocket 6B
sec								
14	—	—	—	168	—	—	100	—
15	—	—	879	428	33	—	336	83
16	—	573	2,315	807	72	—	993	175
17	—	895	5,672	1,380	112	—	2,878	288
18	—	1,968	12,166	1,971	164	292	8,164	360
19	—	4,294	22,640	2,570	219	571	7,316	366
20	33	8,736	29,460	2,864	264	1,196	2,732	316
21	66	13,300	33,160	2,872	321	3,024	1,692	275
22	115	18,860	30,280	2,712	361	6,120	1,056	235
23	181	24,380	22,840	2,511	385	9,968	818	195
24	297	28,280	16,000	2,238	399	11,180	564	170
25	429	29,320	11,900	2,066	406	12,040	483	139
26	725	26,000	9,[illegible]0	1,807	410	10,136	360	125
27	1,140	19,040	7,456	1,672	406	7,292	322	112
28	1,870	12,960	6,160	1,480	397	5,902	280	99
29	3,130	9,998	5,112	1,352	389	5,060	280	86
30	4,560	8,024	4,366	1,223	378	4,476	242	73
31	4,952	6,366	3,830	1,102	365	3,984	242	61
32	4,850	5,440	3,322	999	350	3,566	242	60
33	4,564	4,694	2,868	902	334	3,224	204	58
34	4,530	4,038	2,724	805	318	2,914	204	46
35	4,438	3,682	2,302	759	301	2,700	168	44
36	4,140	3,336	2,064	680	—	2,448	165	—
37	3,708	2,898	1,894	667	—	2,230	123	—
38	3,344	2,294	1,724	585	—	2,074	119	—
[illegible]	2,964	2,112	1,642	530	—	1,968	119	—
40	2,614	1,960	1,462	—	—	1,850	119	—
41	2,390	1,890	1,420	—	—	1,694	119	—
42	2,214	1,596	1,340	—	—	1,582	84	—
43	2,166	1,554	1,208	—	—	1,454	81	—
44	2,224	1,610	1,044	—	—	1,348	81	—
45	2,208	1,610	987	—	—	1,272	81	—
46	2,278	1,538	959	—	—	1,192	81	—
47	2,476	1,286	932	—	—	1,118	81	—
48	2,748	1,430	904	—	—	1,042	81	—
49	3,140	1,358	876	—	—	1,010	81	—
50	3,360	1,077	848	—	—	962	81	—

TABLE 3.6 SUMMARY OF INFORMATION TELEMETERED FROM VARIOUS ROCKETS DURING SHOT ZUNI

Time After Launch	Radiation Intensity, r/hr					
	Rocket 3A	Rocket 4A	Rocket 5A	Rocket 2B	Rocket 3B	Rocket 4B
sec						
11	—	—	—	—	—	60
12	—	—	—	—	105	208
13	—	—	—	88	168	430
14	—	—	—	114	238	761
15	—	—	—	133	375	1,303
16	—	149	31	153	504	2,187
17	115	450	185	173	606	3,617
18	569	1,120	370	179	659	4,604
19	2,534	2,200	586	155	845	3,952
20	4,768	4,615	771	128	1,130	2,215
21	6,449	8,300	804	129	1,402	1,185
22	6,525	11,600	741	169	1,760	785
23	7,165	12,740	710	219	2,237	582
24	6,824	11,063	678	298	2,670	471
25	6,320	8,030	647	415	3,178	379
26	6,468	5,115	615	535	3,482	314
27	6,304	3,380	588	676	3,666	274
28	6,099	2,545	557	828	3,745	235
29	5,472	1,965	540	1,013	3,575	201
30	4,787	1,560	525	1,256	2,870	183
31	4,336	1,258	494	1,536	1,930	167
32	4,200	1,054	463	1,872	1,450	147
33	4,176	914	448	2,182	1,215	127
34	4,130	786	431	2,446	1,005	120
35	4,266	706	415	2,714	859	120
36	4,292	614	414	2,984	756	120
37	4,060	556	382	3,274	684	120
38	3,825	500	368	3,687	618	109
39	3,580	446	360	4,094	551	99
40	3,335	404	350	4,414	515	89
41	3,186	387	338	4,531	480	80
42	3,141	348	310	4,510	444	80
43	3,225	348	291	4,534	409	80
44	3,335	328	278	4,622	381	80
45	3,435	267	260	4,724	366	80
46	3,680	232	247	4,770	350	80
47	3,940	232	228	4,686	328	80
48	3,714	232	216	4,460	310	80
49	3,449	232	209	4,172	293	80
50	3,302	232	203	3,798	283	80

TABLE 3.7 SUMMARY OF INFORMATION TELEMETERED FROM VARIOUS ROCKETS DURING SHOT NAVAJO

Time After Launch	Radiation Intensity, r/hr					
	Rocket 1A	Rocket 2A	Rocket 1B	Rocket 2B	Rocket 5B	Rocket 6B
sec						
12	—	—	—	21	9	—
13	—	—	—	59	38	30
14	—	—	—	104	69	174
15	—	—	—	208	121	392
16	—	—	—	378	229	313
17	—	—	—	651	408	204
18	—	—	—	727	619	189
19	—	—	59	702	741	91
20	—	—	119	576	699	68
21	—	—	199	343	624	38
22	—	74	297	270	402	—
23	—	46	396	264	300	—
24	56	46	555	254	256	—
25	—	45	730	234	229	—
26	—	45	853	219	224	—
27	—	44	1,010	199	215	—
28	—	44	1,180	182	211	—
29	—	43	1,270	163	203	—
30	—	43	1,410	142	186	—
31	—	42	1,580	125	176	—
32	—	42	1,720	112	150	—
33	—	51	1,820	108	146	—
34	—	68	1,780	98	132	—
35	—	76	1,720	90	125	—
36	—	55	1,590	77	115	—
37	—	42	1,450	73	104	—
38	—	—	1,290	70	96	—
39	—	—	1,190	70	89	—
40	—	—	1,010	69	63	—
41	—	—	930	59	82	—
42	—	—	832	55	76	—
43	—	—	730	53	75	—
44	—	—	620	53	72	—
45	—	—	574	53	—	—
46	—	—	493	52	—	—
47	—	—	469	49	—	—
48	—	—	416	43	—	—
49	—	—	396	42	—	—
50	—	—	376	39	—	—

TABLE 3.8 SUMMARY OF INFORMATION TELEMETERED FROM ROUND THREE DURING SHOT TEWA

Time After Launch	Radiation Intensity	Time After Launch	Radiation Intensity
sec	r/hr	sec	r/hr
12	8	26	1,448
13	21	27	1,298
14	79	28	1,182
15	245	29	1,043
16	539	30	913
17	1,029	31	808
18	1,720	32	742
19	2,400	33	663
20	2,768	34	628
21	2,746	35	563
22	2,459	36	508
23	2,143	37	483
24	1,860	38	427
25	1,616	39	408

TABLE 3.9 ROCKET CONTAMINATION FROM VARIOUS SHOTS

Shot	Rocket	Peak, r/hr	Residual, r/hr	Percentage Based on Peak
Cherokee	2A	5,000	0	0.0
	3A	30,000	1,500	5.0
	4A	33,800	600	1.8
	5A	2,950	230	7.8 *
	6A	434	110	25.4 *
	2B	12,800	774	6.0
	4B	10,300	81	0.8
	6B	386	61	15.7 *
Zuni	3A	7,510	41	0.5
	4A	12,800	61	0.5
	3B	3,780	35	0.9
	4B	4,820	40	0.8
Navajo	2B	740	28	3.8
	4B	1,820	59	3.2
	5B	746	36	4.8
Tewa	3	2,900	208	7.2 *

* Data from these rockets were corrected for contamination.

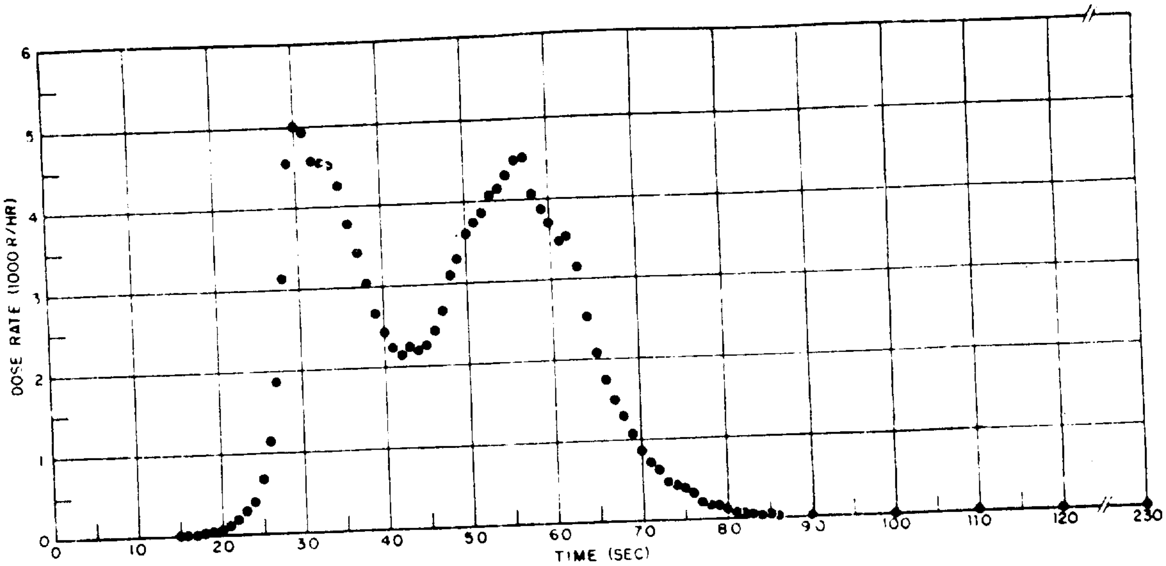

Figure 3.1 Typical roentgen information versus time plot for Shot Cherokee, Round 2A.

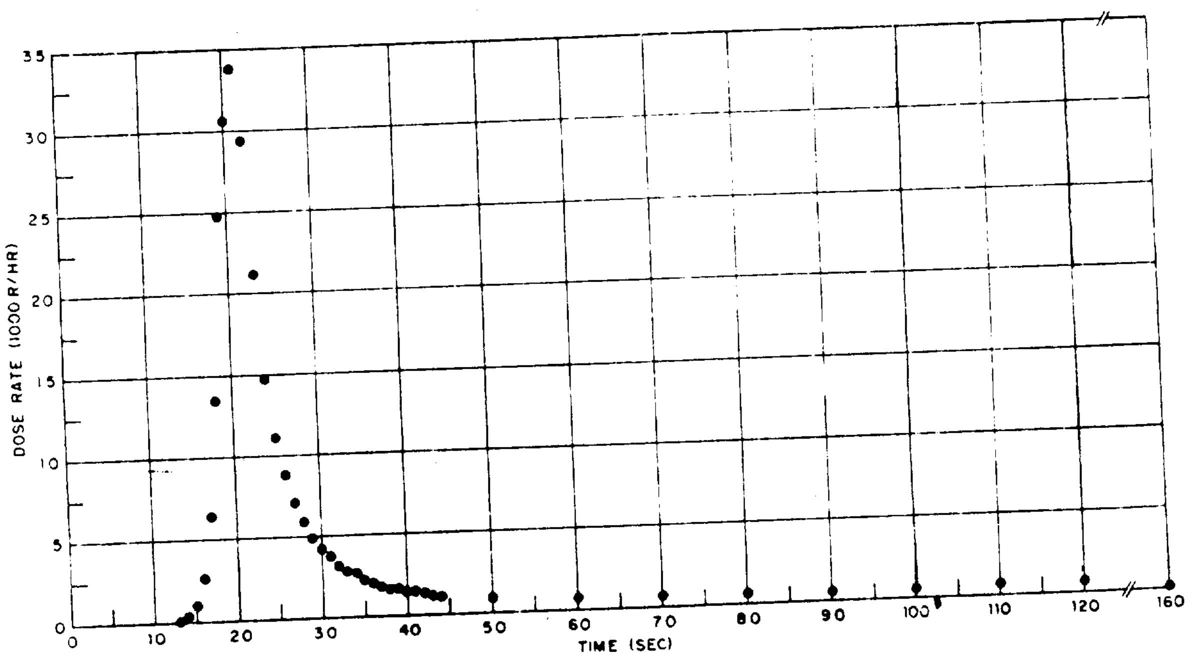

Figure 3.2 Typical roentgen information versus time plot for Shot Cherokee, Round 4A.

in excess of 6 percent of the peak readings. The data from these rockets were corrected by subtracting the quantity

$$\frac{\int_0^t r\,dt}{\int_0^{t_R} r\,dt} R$$

from the rocket readings, where t = the time after the start (rocket enters cloud) of the rise of the record, r = reading of the rocket at time t, R = residual reading due to contamination of the rocket, and t_R = the time at which the readings are down to R.

Chapter 4
DISCUSSION

4.1 GENERAL OPERATION OF THE SYSTEM

At the onset of this experiment, great concern was expressed about the ability of the telemetering system to transmit information out of the highly ionized air expected to be encountered. One theoretical calculation indicated that the 1 watt of power radiated from the rocket antenna would be attenuated to the extent that information carried by it would be below the noise level when received. Another calculation indicated the opposite. Both calculations were sensitive to small changes in the parameters assumed. Fields as high as 3×10^4 r/hr were encountered with no apparent loss of information. Thus, this concern for the ability of the system to transmit through the highly ionized air seems unfounded.

The system as a whole was made up of commercially available components, (the telemetering transmitters and receivers and the tape recorders) and newly developed experimental components (the rockets and radiation transducers). In general, the performance of the rockets, transducers, and tape recorders may be characterized as satisfactory; that of the transmitters and receivers was less than satisfactory in this particular, unusually rigorous service.

The only difficulties experienced in the field with the transducers could be attributed to faulty packaging. Several transducers failed before they were installed in the rocket heads, probably because the compound in which the electronic components were potted shrunk and cracked the tubes. However, calibrating and testing the detectors before installing them in the rockets insured reliable units.

Drift of the frequency of the transmitters necessitated operating the receivers with their automatic frequency-control circuits turned on so that the receivers might follow the changing frequencies of the transmitters. As a result, two or three receivers occasionally locked on the same transmitter and duplicated the information. On other occasions, receivers changed from one transmitter to another during flight. These effects were due to the fact that a given carrier from one rocket could take control of two or more receivers when their automatic frequency controls were not locked onto a carrier. This capture of control could occur either during the launching period, before all the carriers were on the air, or during the flight period, generally as a result of a strong disturbance in the carrier previously controlling the receiver.

A warm-up time of 12 hours or more was required to reduce appreciable drift in receiver frequency. As mentioned in Chapter 2, the Site Nan receiving station was unmanned during the shot. Since it was necessary to leave this station about 12 hours before shot time, its receiving equipment had to be turned on 24 hours before each shot.

4.2 ACTIVITY IN THE CLOUD

To obtain a measure of the amount of gamma emitters in the cloud, it was necessary to convert roentgen intensity readings to curies of gamma emitters per unit volume. The roentgen activity at a given place in the clouds depends upon the number of photons being emitted per unit time per unit volume, the energy of the photons, and the density of the medium (function of altitude).

The number of Mev per cubic meter per second produced in air containing C curies (In this treatment, it is arbitrarily assumed that there is one photon per disintegration, so a curie is to be taken to mean 3.7×10^{10} photons per second throughout the chapter.) of gamma emitters per cubic meter of an average effective energy of E Mev is 3.7×10^{10} C E Mev/sec/m^3. If this body of air is infinite in extent and in equilibrium, then the energy emitted per unit volume must be equal to the energy absorbed per unit volume. If this air is a standard atmosphere, then the definition of the roentgen leads to the relation, $1 \text{ r} = 6.77 \times 10^4 \text{ Mev/cm}^3$ from which 3.7×10^{10} C E Mev/sec/m^3 being absorbed yields a field of 1,970 C E r/hr in a standard atmosphere. If a medium has the same absorption and scattering coefficients per gram as the standard atmosphere, then the roentgen field is inversely proportional to density and is given by

$$I = 1{,}970 \text{ C E } \frac{\rho \text{ standard air}}{\rho \text{ medium}}$$

or

$$I = 2.54 \frac{\text{C E}}{\rho} \tag{4.1}$$

where I is the intensity in r/hr inside of an infinite medium of homogeneously mixed emitters, E is the average effective energy of the photons in Mev, C is the number of curies per cubic meter and ρ is the density of the medium in grams per cubic centimeter.

Figure 4.1 is a plot of the number of millicuries per cubic meter required to give a field of 1 r/hr versus altitude. This plot was obtained from Equation 4.1 in which the value for the

TABLE 4.1 COMPARISON OF THEORETICAL AND EXPERIMENTAL ESTIMATES OF CLOUD ACTIVITY

Source	Total Photons per Second		
	Cherokee	Zuni	Navajo
		7 minute	
From cloud profiles	24.5×10^{22}	5.6×10^{22}	—
Theoretical: fiss. prod.	29.3×10^{22}	7.69×10^{22}	3.69×10^{22}
Theoretical: U^{239}*	4.7×10^{22}	1.07×10^{22}	0.13×10^{22}
		15 minute	
From cloud profiles	11.0×10^{22}	3.7×10^{22}	0.68×10^{22}
Theoretical: fiss. prod.	14.8×10^{22}	3.92×10^{22}	1.89×10^{22}
Theoretical: U^{239}*	3.7×10^{22}	0.84×10^{22}	0.12×10^{22}

* Activity due to the 0.07 Mev gamma from U^{239} is on the borderline for detection by the radiation transducer, and therefore the bulk of activity recorded arises from fission products.

energy was assumed to be 1.25 Mev and those for the densities were taken from Reference 6. From Figure 4.1 it is evident that altitude is an important consideration in interpreting the information telemetered by rockets.

The telemetered information tabulated in Appendix A is converted to millicuries per cubic meter as a function of range and altitude of the rocket by the use of Figure 4.1 and computed trajectories. Figures 4.2 through 4.6 were prepared from this information by plotting rocket trajectories and drawing contour lines through points of equal activity concentration, thus giving activity profiles through the clouds in the plane of the rocket trajectories. Since the usable parts of the trajectories were mostly through the portions of the clouds between the rocket launching point and ground zero, only this half of the profile is sketched. Figures 4.2 and 4.3 give the semiprofiles for Shot Cherokee at 7 and 15 minutes after detonation; Figures 4.4 and 4.5 give the semiprofiles for Shot Zuni at 7 and 15 minutes after detonation; and, Figure 4.6 gives the semiprofile for Shot Navajo at 15 minutes after detonation. The wind profile in the plane of the rocket trajectories has been computed and is shown on the 15-minute clouds. This line is a projection on the plane of the rocket trajectories of the vertical line above ground zero as it would have been distorted in 15 minutes by winds. It provides a means for visualizing the amount of shear to be expected in the clouds.

During Shot Navajo, Round 2B, fired 15 minutes and 2 seconds after detonation, and Round 5B, fired 15 minutes and 8 seconds after detonation, were launched at the same quadrant elevation to check the reproducibility of information from rockets following the same trajectories at essentially the same time. Figure 4.7 shows activities measured by rounds as a function of time after launching of individual rockets. Peak intensities recorded agreed within 2 percent. The areas under the curves, which gave a measure of total activity measured by the rockets,

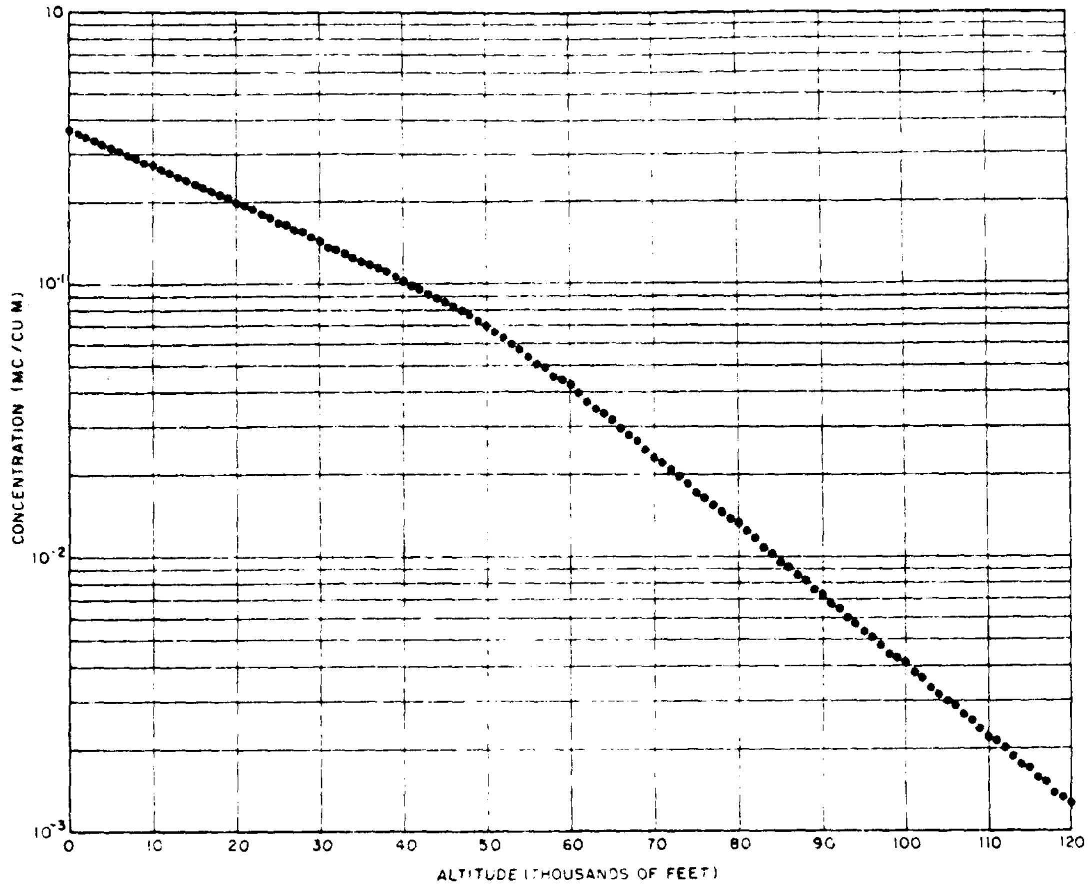

Figure 4.1 Concentration of gamma emitters to produce 1 r/hr field in an infinite volume of air.

agreed within 7 percent, and the times to peak activity were 1 second apart. Since 1 second is the sampling period in the readout system, the peaks could be between 1.5 and 0.5 seconds apart.

Of the four rockets fired during Shot Tewa, only one produced useful radiological information. However, it is of interest to compare the one round producing information with a round fired at the same time after detonation, at the same quadrant elevation of launch and as far as can be determined, at a similar part of Shot Cherokee. Round 3 at Shot Tewa and Round 5A at Shot Cherokee were both fired at 7 minutes after detonation and were launched at a quadrant elevation of 75 degrees. Figure 4.8 shows a comparison of the data obtained from the two rounds. The lower curve shows the Shot Tewa results normalized to the same fission to total yield ratio as Shot Cherokee.

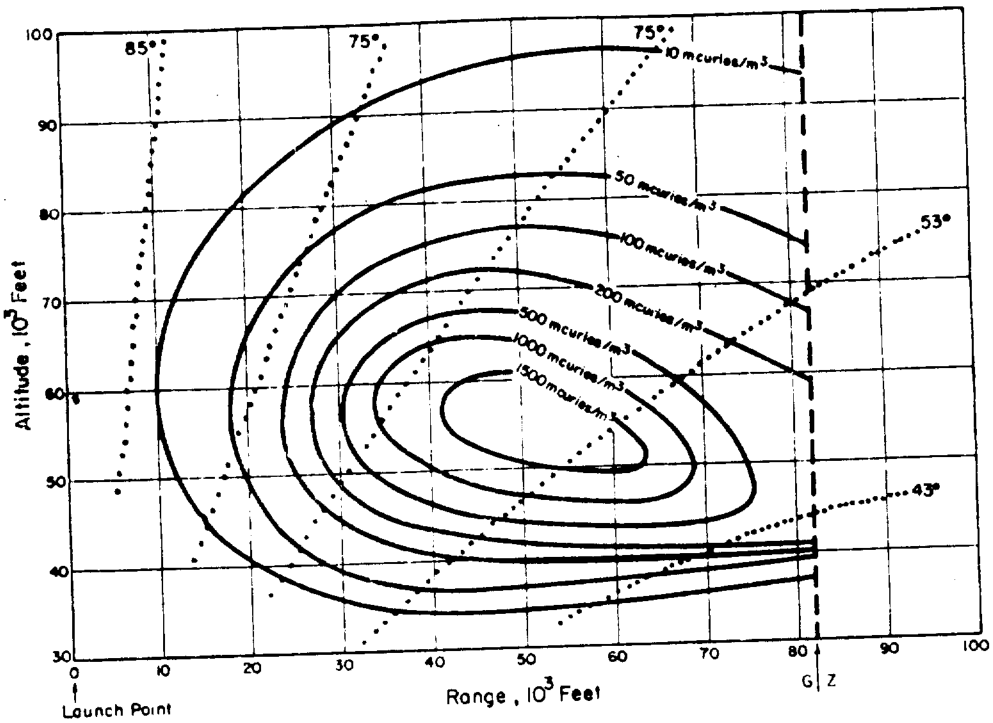

Figure 4.2 Activity distribution in the plane of rocket trajectories 7 minutes after Shot Cherokee.

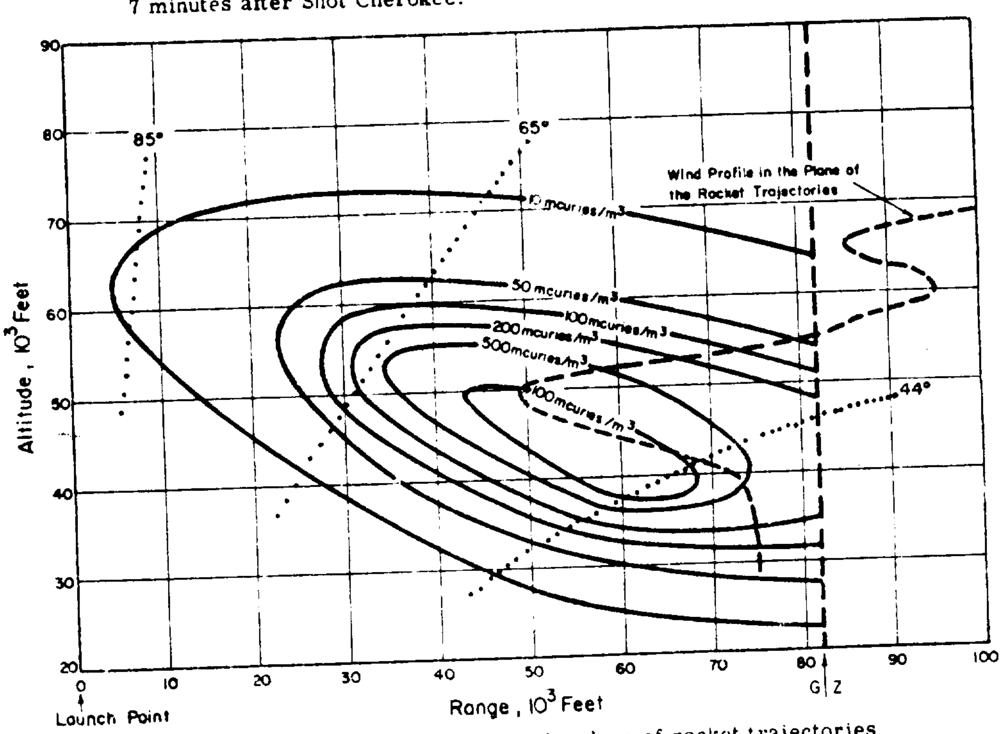

Figure 4.3 Activity distribution in the plane of rocket trajectories 15 minutes after Shot Cherokee.

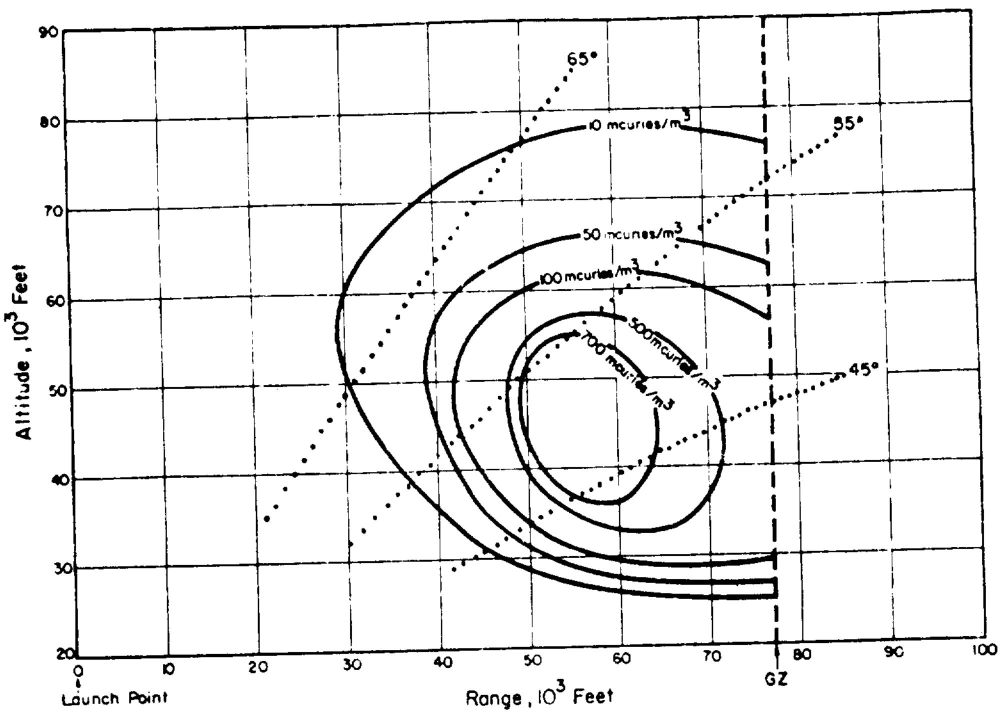

Figure 4.4 Activity distribution in the plane of rocket trajectories 7 minutes after Shot Zuni.

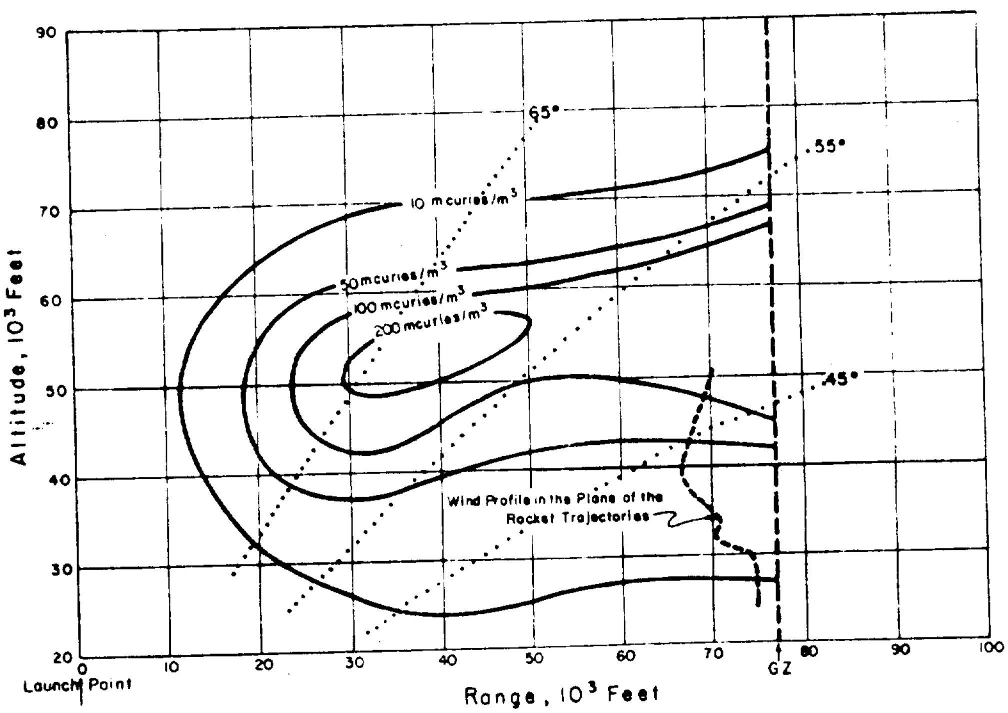

Figure 4.5 Activity distribution in the plane of rocket trajectories 15 minutes after Shot Zuni.

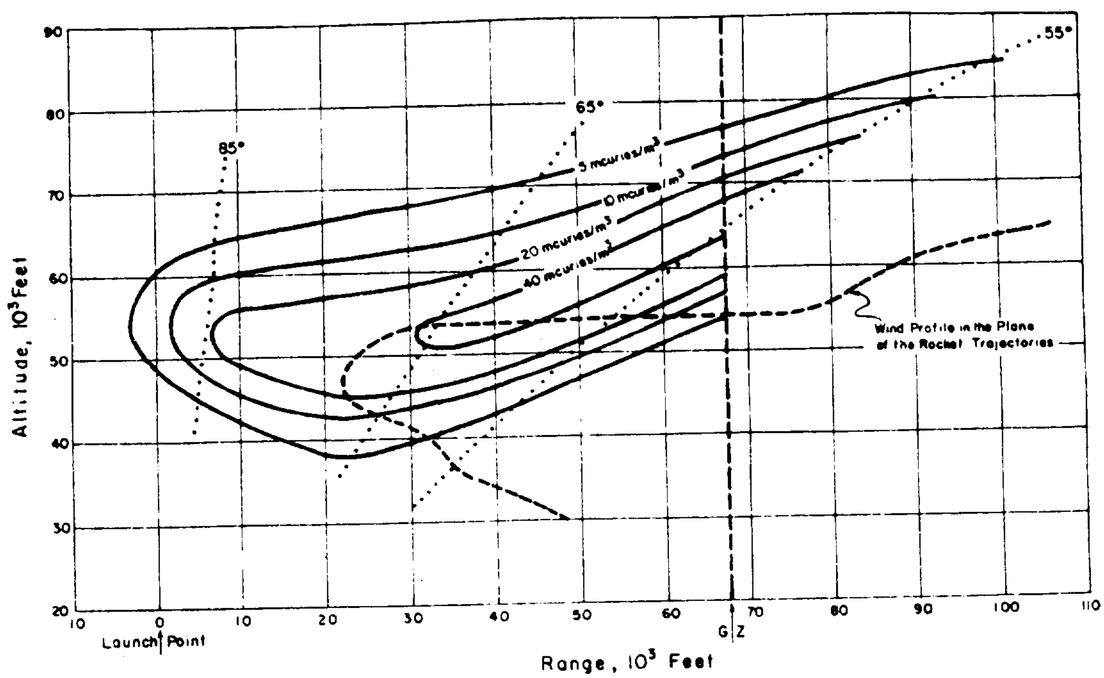

Figure 4.6 Activity distribution in the plane of rocket trajectories 15 minutes after Shot Navajo.

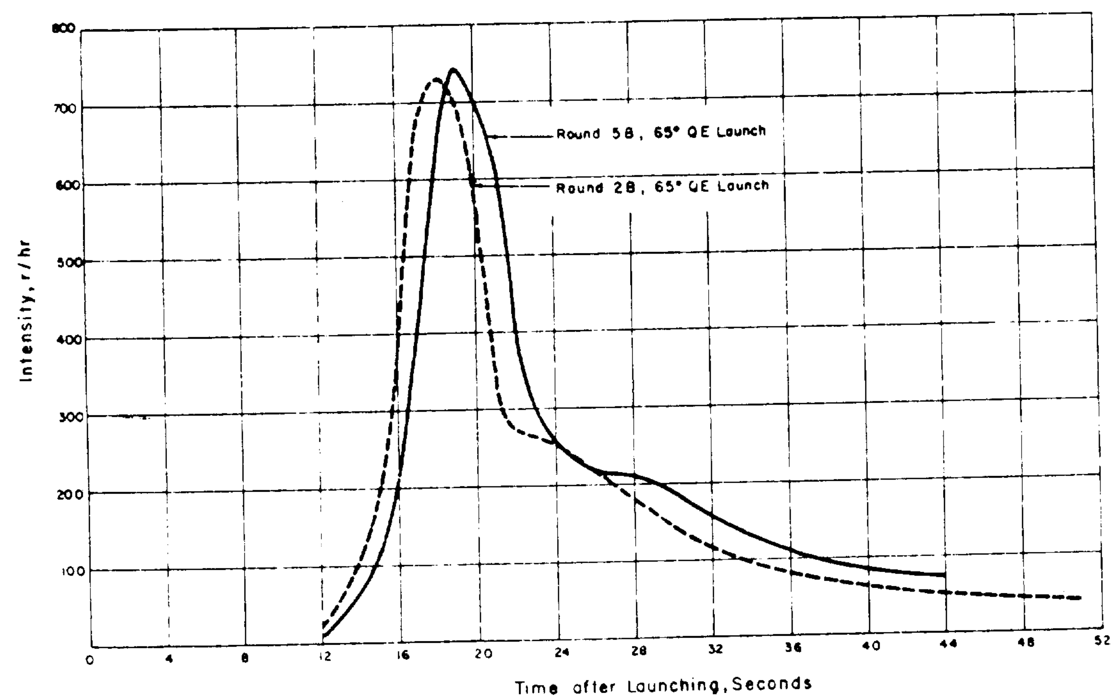

Figure 4.7 Reproducibility of similar rounds fired 15 minutes after Shot Navajo.

The shapes of the curves are similar and the normalized Shot Tewa curve is lower, as might be expected from the higher fallout rates from a water-reef shot as compared to an air burst. This agreement is not of great significance since these rockets went through areas near the edges of the clouds. However, the single set of data

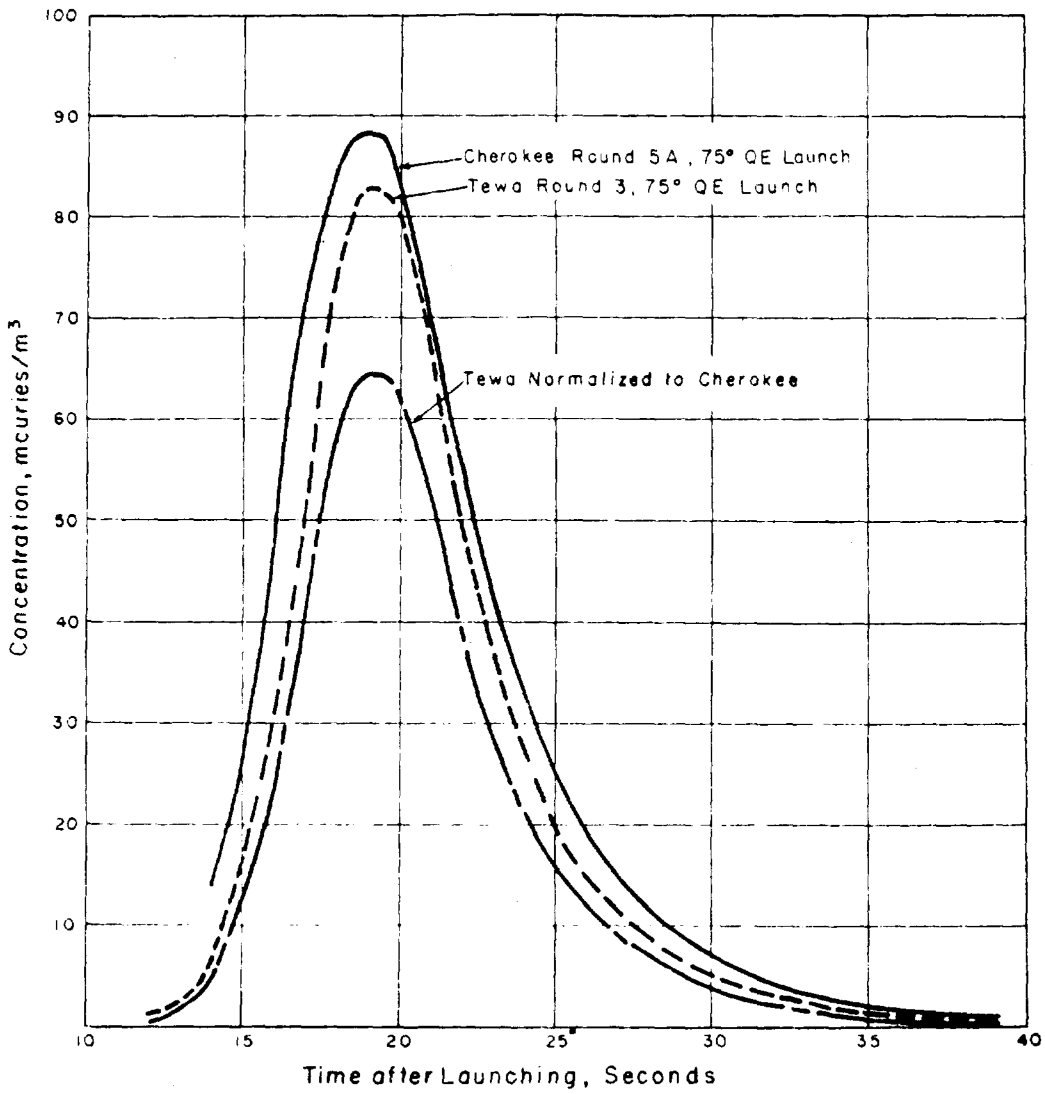

Figure 4.8 Comparison of similar trajectories during Shots Cherokee and Tewa.

obtained from Shot Tewa was not inconsistent with data from Shot Cherokee.

Two of the rockets that were fired through the Shot Navajo stem yielded data. Rocket 1A yielded a peak concentration of 9.3 mc/m^3 while Rocket 2A indicated a peak concentration of 12.6 mc/m^3. On the basis of the 15-minute measurements made in the cloud, it is estimated that these concentrations would be about 10 percent of the peak concentration in the main body of the cloud at the same time. These rockets passed through the stem at an altitude of about 25,000 feet.

Having constructed the profiles of Figures 4.2 through 4.6, it is possible to obtain an estimate of the total number of photons per second at the time for which the profile is drawn. This estimate of the total activity is made by rotating the profile about its vertical axis through 2π radians and integrating. Table 4.1 gives these estimates and compares them with the theoretical estimates of cloud activity given in Table 1.1.

Except for the 15-minute Zuni cloud, estimations, based on rocket data, of the total number of photons in the clouds were not influenced by theoretical estimates. Even so, the results agreed closely. The uncertainties involving such items as energy of the photons, axial symmetry of the clouds, and positions of rockets are such that the close agreement might be fortuitous, but it may be concluded that the theoretical values and those derived from rocket data agree, at least, in order of magnitude.

4.3 CONTAMINATION OF THE ROCKET

The possible contamination of the rocket itself was considered important since it would affect the measurements obtained by the radiation transducer. At the velocities attained by the rocket, aerodynamic heating causes the paint to burn off the skin of the rocket, leaving a blackened, charred surface. Subsequent contamination of this surface could cause high background detection in the rocket head. However, examination of the data obtained revealed background counting rates above 6 percent in terms of the peak readings in only four cases and in these cases the peak readings were relatively low. These four sets of data were corrected (see Section 3.2) for contamination of the rocket; however, even if they had not been, the resulting cloud profiles would not have been significantly altered.

Chapter 5
SUMMARY

5.1 CONCLUSIONS

It is concluded that a rocket-borne radiation detection unit with a telemetering transmitter for relaying information to a ground station constitutes a practical system for exploring the spatial distribution of radioactivity in the cloud resulting from a large-yield nuclear detonation. Performance of the system developed for this project may be characterized as generally satisfactory, particularly with respect to the rocket itself and the radiation transducer. Instability of the transmitter-receiver combination resulted in some telemetering failures and consequent loss of data.

Radioactive fields of intensities as high as 3.4×10^4 r/hr were encountered with no apparent attenuation of the telemetering signal.

Information from a salvo of rockets fired through the Shot Navajo stem at 25,000 feet indicate the peak activity at that level to be about 10 percent of the peak activity in the cloud. Since the volume of the cloud is about two orders of magnitude larger than that of the stem, it is estimated that the order of 0.1 percent of the total activity is in the stem.

Contamination of the rocket surfaces was not serious. In terms of peak readings, the maximum contamination encountered was higher than 6 percent on only four rockets. In these cases the peak activity encountered by the rockets was relatively low.

Values derived from rocket data, for the number of photons per second in the clouds agreed with theoretical estimates in order of magnitude.

5.2 RECOMMENDATIONS

It is recommended that further development and refinement be made in order that the system may be available for making early time radiological surveys of nuclear clouds. It is further recommended that the feasibility of using similar systems for measuring energy spectra and decay and for obtaining early-time cloud samples be investigated.

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Appendix
SUMMARY of DATA

This Appendix summarizes the data used in preparing the cloud profiles. Trajectory tables and radiation intensity versus time data were supplied by the Cooper Development Corporation. The radiation intensity data were converted to concentration by applying factors from Figure 4.1.

TABLE A.1 SHOT CHEROKEE, ROUND 2A, QE 43 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration	Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3	sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
20	54.8	33.4	12.7×10^{-2}	33	4.18	52	109.7	46.7	7.96×10^{-2}	3,752	298.6
21	56.9	34.4	12.2×10^{-2}	66	8.04	53	111.1	46.5	8.04×10^{-2}	3,884	312.1
22	59.0	35.4	11.7×10^{-2}	115	13.7	54	112.4	46.2	8.11×10^{-2}	4,074	330.5
23	61.2	36.4	11.5×10^{-2}	181	20.9	55	113.7	46.0	8.19×10^{-2}	4,166	341.2
24	63.3	37.4	11.2×10^{-2}	297	33.2	56	114.9	45.7	8.27×10^{-2}	4,348	359.6
25	65.4	38.4	10.8×10^{-2}	429	46.2	57	116.1	45.5	8.35×10^{-2}	4,504	376.1
26	67.4	39.2	10.4×10^{-2}	725	75.0	58	117.4	45.2	8.43×10^{-2}	4,428	373.4
27	69.3	39.9	10.1×10^{-2}	1,140	115.4	59	118.6	45.0	8.51×10^{-2}	4,022	342.4
28	71.3	40.7	9.87×10^{-2}	1,870	185.4	60	119.8	44.7	8.60×10^{-2}	3,834	329.6
29	73.2	41.4	9.62×10^{-2}	3,130	301.2	61	120.9	44.2	8.74×10^{-2}	3,646	318.8
30	75.2	42.2	9.39×10^{-2}	4,560	428.0	62	122.1	43.8	8.89×10^{-2}	3,514	312.3
31	77.0	42.7	9.23×10^{-2}	4,952	456.9	63	123.2	43.3	9.03×10^{-2}	3,580	323.3
32	78.7	43.2	9.07×10^{-2}	4,850	439.8	64	124.4	42.9	9.17×10^{-2}	3,016	276.7
33	80.5	43.7	8.91×10^{-2}	4,564	406.8	65	125.5	42.4	9.32×10^{-2}	2,430	226.5
34	82.2	44.2	8.76×10^{-2}	4,530	396.6	66	126.5	41.9	9.49×10^{-2}	2,006	190.4
35	84.0	44.7	8.60×10^{-2}	4,438	381.5	67	127.5	41.3	9.66×10^{-2}	1,698	164.0
36	85.6	45.0	8.51×10^{-2}	4,140	352.2	68	128.4	40.8	9.83×10^{-2}	1,450	142.6
37	87.3	45.3	8.42×10^{-2}	3,708	312.2	69	129.4	40.2	10.0×10^{-2}	1,246	124.8
38	88.9	45.5	8.33×10^{-2}	3,344	278.6	70	130.4	39.7	10.2×10^{-2}	1,021	105.1
39	90.6	45.8	8.24×10^{-2}	2,964	244.4	71	131.4	39.1	10.4×10^{-2}	842	87.4
40	92.2	46.1	8.16×10^{-2}	2,614	213.2	72	132.4	38.4	10.7×10^{-2}	688	74.0
41	93.7	46.3	8.09×10^{-2}	2,390	193.3	73	133.3	37.8	11.1×10^{-2}	586	64.9
42	95.2	46.5	8.02×10^{-2}	2,214	177.5	74	134.3	37.1	11.2×10^{-2}	474	53.4
43	96.8	46.8	7.95×10^{-2}	2,166	172.1	75	135.2	36.5	11.5×10^{-2}	381	43.9
44	98.3	47.0	7.88×10^{-2}	2,224	175.2	76	136.2	35.8	11.8×10^{-2}	319	37.6
45	99.8	47.2	7.81×10^{-2}	2,208	172.4	77	137.2	35.0	12.0×10^{-2}	262	31.9
46	101.3	47.2	7.81×10^{-2}	2,278	177.9	78	138.1	34.3	12.2×10^{-2}	205	25.1
47	102.7	47.2	7.81×10^{-2}	2,476	193.3	79	139.1	33.5	12.6×10^{-2}	168	21.1
48	104.2	47.2	7.81×10^{-2}	2,748	214.6	80	140.0	32.8	13.0×10^{-2}	157	20.4
49	105.6	47.2	7.81×10^{-2}	3,140	245.2	81	140.8	32.0	13.2×10^{-2}	108	14.3
50	107.1	47.2	7.81×10^{-2}	3,360	262.3	82	141.6	31.2	13.4×10^{-2}	78	10.7
51	108.4	47.0	7.88×10^{-2}	3,626	285.8	83	142.4	30.3	14.0×10^{-2}	59	8.29

TABLE A.2 SHOT CHEROKEE, ROUND 3A, QE 53 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration	Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3	sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
16	39.4	37.8	11.1×10^{-2}	573	63.4	58	121.3	83.7	1.03×10^{-2}	1,365	14.0
17	41.7	39.8	10.2×10^{-2}	895	90.9	59	123.0	84.0	1.01×10^{-2}	1,401	14.2
18	44.1	41.8	9.51×10^{-2}	1,968	187.2	60	124.8	84.3	0.990×10^{-2}	1,433	14.2
19	46.4	43.8	8.88×10^{-2}	4,294	381.4	61	126.6	84.5	0.976×10^{-2}	1,451	14.2
20	48.8	45.8	8.25×10^{-2}	8,736	720.9	62	128.4	84.7	0.961×10^{-2}	1,469	14.1
21	50.9	47.4	7.73×10^{-2}	13,300	1,028.6	63	130.2	85.0	0.947×10^{-2}	1,487	14.1
22	53.1	49.1	7.21×10^{-2}	18,860	1,360.8	64	132.0	85.2	0.939×10^{-2}	1,505	14.1
23	55.2	50.7	6.69×10^{-2}	24,380	1,633.4	65	133.8	85.4	0.932×10^{-2}	1,523	14.2
24	57.4	52.4	6.28×10^{-2}	28,280	1,749.1	66	135.6	85.4	0.930×10^{-2}	1,541	14.4
25	59.5	54.0	5.67×10^{-2}	29,320	1,662.4	67	137.4	85.5	0.929×10^{-2}	1,559	14.5
26	61.5	55.5	5.20×10^{-2}	26,000	1,353.9	68	139.3	85.5	0.928×10^{-2}	1,577	14.6
27	63.6	56.9	4.89×10^{-2}	19,040	931.6	69	141.1	85.6	0.927×10^{-2}	1,595	14.8
28	65.6	58.4	4.59×10^{-2}	12,960	582.0	70	142.9	85.6	0.925×10^{-2}	1,610	14.9
29	67.7	59.8	4.27×10^{-2}	9,998	427.5	71	144.6	85.4	0.930×10^{-2}	1,610	15.0
30	69.7	61.3	3.84×10^{-2}	8,024	308.4	72	146.3	85.3	0.936×10^{-2}	1,610	15.1
31	71.7	62.5	3.53×10^{-2}	6,366	224.9	73	148.1	85.1	0.941×10^{-2}	1,610	15.2
32	73.6	63.8	3.34×10^{-2}	5,440	181.8	74	149.8	85.0	0.948×10^{-2}	1,610	15.2
33	75.6	65.0	3.15×10^{-2}	4,694	147.7	75	151.5	84.8	0.948×10^{-2}	1,610	15.4
34	77.5	66.3	2.91×10^{-2}	4,038	117.5	76	153.0	84.4	0.981×10^{-2}	1,610	15.8
35	79.5	67.5	2.69×10^{-2}	3,682	99.0	77	154.6	84.1	1.00×10^{-2}	1,610	16.2
36	81.4	68.6	2.52×10^{-2}	3,336	84.2	78	156.1	83.7	1.03×10^{-2}	1,610	15.5
37	83.3	69.7	2.35×10^{-2}	2,898	68.2	79	157.7	83.4	1.05×10^{-2}	1,610	16.9
38	85.1	70.7	2.23×10^{-2}	2,294	51.1	80	159.2	83.0	1.07×10^{-2}	1,610	17.2
39	87.0	71.8	2.10×10^{-2}	2,112	44.4	81	160.9	82.6	1.11×10^{-2}	1,610	17.9
40	88.9	72.9	1.96×10^{-2}	1,960	38.5	82	162.5	82.1	1.16×10^{-2}	1,610	18.6
41	90.7	73.7	1.87×10^{-2}	1,890	35.3	83	164.2	81.7	1.19×10^{-2}	1,610	19.1
42	92.5	74.5	1.77×10^{-2}	1,596	28.2	84	165.8	81.2	1.22×10^{-2}	1,610	19.6
43	94.4	75.2	1.68×10^{-2}	1,554	26.2	85	167.5	80.8	1.25×10^{-2}	1,610	20.1
44	96.2	76.0	1.64×10^{-2}	1,610	26.4	86	169.1	80.2	1.30×10^{-2}	1,610	20.9
45	98.0	76.8	1.56×10^{-2}	1,610	25.1	87	170.7	79.7	1.34×10^{-2}	1,610	21.6
46	99.8	77.5	1.49×10^{-2}	1,538	23.0	88	172.3	79.1	1.38×10^{-2}	1,610	22.2
47	101.6	78.2	1.44×10^{-2}	1,286	18.5	89	173.9	78.6	1.42×10^{-2}	1,610	22.8
48	103.5	79.0	1.39×10^{-2}	1,430	19.9	90	175.5	78.0	1.45×10^{-2}	1,602	23.2
49	105.3	79.7	1.34×10^{-2}	1,358	18.2	91	177.0	77.4	1.50×10^{-2}	1,566	23.6
50	107.1	80.4	1.28×10^{-2}	1,077	13.8	92	178.4	76.8	1.56×10^{-2}	1,530	23.9
51	108.9	80.9	1.24×10^{-2}	1,113	13.8	93	179.9	76.2	1.62×10^{-2}	1,494	24.2
52	110.7	81.4	1.21×10^{-2}	1,149	13.9	94	181.3	75.6	1.66×10^{-2}	1,458	24.3
53	112.4	81.8	1.18×10^{-2}	1,185	14.0	95	182.8	75.0	1.70×10^{-2}	1,422	24.2
54	114.2	82.3	1.14×10^{-2}	1,221	13.9	96	184.6	73.9	1.84×10^{-2}	1,386	25.5
55	116.0	82.8	1.09×10^{-2}	1,257	13.7	97	186.3	72.8	1.98×10^{-2}	1,350	26.7
56	117.8	83.1	1.06×10^{-2}	1,293	13.8	98	188.1	71.7	2.12×10^{-2}	1,314	27.8
57	119.5	83.4	1.05×10^{-2}	1,329	13.9	99	189.8	70.6	2.24×10^{-2}	1,278	28.6

TABLE A.3 SHOT CHEROKEE, ROUND 4A, QE 65 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
15	27.3	44.7	85.9×10^{-3}	879	75.6
16	29.2	47.5	77.1×10^{-3}	2,315	178.7
17	31.1	50.3	68.4×10^{-3}	5,672	388.0
18	32.9	53.1	59.5×10^{-3}	12,166	725.0
19	34.8	55.8	50.8×10^{-3}	22,640	1,151.2
20	36.6	58.6	44.5×10^{-3}	29,460	1,312.8
21	38.4	61.1	38.9×10^{-3}	33,160	1,291.9
22	40.2	63.6	33.6×10^{-3}	30,280	1,019.0
23	42.0	66.1	29.3×10^{-3}	22,840	670.7
24	43.7	68.6	25.1×10^{-3}	16,000	402.8
25	45.5	71.1	21.8×10^{-3}	11,900	260.2
26	47.2	73.4	19.0×10^{-3}	9,280	176.8
27	49.0	75.6	16.6×10^{-3}	7,456	123.9
28	50.7	77.9	14.5×10^{-3}	6,160	89.8
29	52.4	80.1	13.0×10^{-3}	5,112	66.7
30	54.1	82.4	11.2×10^{-3}	4,366	49.2
31	55.8	84.5	9.77×10^{-3}	3,830	37.4
32	57.5	86.6	8.76×10^{-3}	3,322	29.1
33	59.2	88.6	7.78×10^{-3}	2,868	22.3
34	60.9	90.7	6.90×10^{-3}	2,724	18.8
35	62.6	92.8	6.08×10^{-3}	2,302	14.0
36	64.3	94.7	5.45×10^{-3}	2,064	11.2
37	66.0	96.6	4.86×10^{-3}	1,894	9.20
38	67.7	98.5	4.34×10^{-3}	1,724	7.48
39	69.3	100.4	3.99×10^{-3}	1,642	6.55
40	71.0	102.2	3.54×10^{-3}	1,462	5.18
41	72.7	104.0	3.16×10^{-3}	1,420	4.48
42	74.4	105.7	2.89×10^{-3}	1,340	3.87
43	76.0	107.4	2.61×10^{-3}	1,208	3.16
44	77.7	109.1	2.34×10^{-3}	1,044	2.44
45	79.4	110.8	2.15×10^{-3}	987	2.12
46	81.0	112.4	1.97×10^{-3}	959	1.89
47	82.7	113.9	1.77×10^{-3}	932	1.65
48	84.4	115.5	1.64×10^{-3}	904	1.48
49	86.0	117.0	1.50×10^{-3}	876	1.32
50	87.7	118.6	1.35×10^{-3}	848	1.14

TABLE A.4 SHOT CHEROKEE, ROUND 5A, QE 75 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
14	15.9	46.4	80.8×10^{-3}	168	13.6
15	17.2	50.1	69.1×10^{-3}	428	29.6
16	18.4	53.3	52.8×10^{-3}	807	47.4
17	19.6	56.6	49.4×10^{-3}	1,380	68.3
18	20.9	59.8	42.7×10^{-3}	1,971	84.2
19	22.1	63.1	34.4×10^{-3}	2,570	88.4
20	23.3	66.4	28.8×10^{-3}	2,864	82.6
21	24.5	69.4	24.0×10^{-3}	2,872	68.9
22	25.6	72.4	20.3×10^{-3}	2,717	55.1
23	26.8	75.4	16.8×10^{-3}	2,511	42.1
24	28.0	78.4	14.3×10^{-3}	2,238	30.0
25	29.2	81.4	12.1×10^{-3}	2,066	25.0
26	30.3	84.1	10.0×10^{-3}	1,807	18.1
27	31.5	86.9	8.55×10^{-3}	1,672	14.3
28	32.6	89.7	7.33×10^{-3}	1,480	10.8
29	33.8	92.5	6.22×10^{-3}	1,352	8.42
30	34.9	95.3	5.27×10^{-3}	1,223	6.44
31	36.1	97.9	4.45×10^{-3}	1,102	4.90
32	37.2	100.5	4.95×10^{-3}	999	3.95
33	38.4	103.1	3.30×10^{-3}	902	2.98
34	39.5	105.7	2.89×10^{-3}	805	2.33
35	40.6	108.2	2.48×10^{-3}	759	1.88
36	41.8	110.7	2.16×10^{-3}	680	1.47
37	42.9	113.1	1.88×10^{-3}	667	1.25
38	44.0	115.5	1.64×10^{-3}	585	0.957
39	45.2	118.0	1.40×10^{-3}	530	0.739

TABLE A.5 SHOT CHEROKEE, ROUND 6A, QE 85 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
15	5.9	52.9	60.2×10^{-3}	33	1.98
16	6.3	56.4	49.8×10^{-3}	72	3.58
17	6.7	59.9	42.6×10^{-3}	112	4.77
18	7.2	63.4	33.9×10^{-3}	164	5.56
19	7.6	67.0	27.7×10^{-3}	219	6.08
20	8.0	70.5	22.5×10^{-3}	264	5.94
21	8.4	73.8	18.6×10^{-3}	321	5.96
22	8.8	77.0	15.4×10^{-3}	361	5.55
23	9.2	80.3	12.9×10^{-3}	385	4.98
24	9.6	83.5	10.4×10^{-3}	399	4.14
25	10.0	86.8	8.62×10^{-3}	406	3.50
26	10.4	89.9	7.28×10^{-3}	410	2.98
27	10.8	92.9	6.02×10^{-3}	406	2.44
28	11.2	96.0	5.05×10^{-3}	397	2.00
29	11.7	99.0	4.24×10^{-3}	389	1.65
30	12.1	102.1	3.59×10^{-3}	378	1.36
31	12.5	105.0	2.99×10^{-3}	365	1.09
32	12.9	107.9	2.54×10^{-3}	350	0.890
33	13.3	110.7	2.16×10^{-3}	334	0.720
34	13.7	113.6	1.81×10^{-3}	318	0.575
35	14.1	116.5	1.55×10^{-3}	301	0.465

TABLE A.6 SHOT CHEROKEE, ROUND 2B, QE 44 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
18	49.4	31.8	13.3×10^{-2}	292	38.8
19	51.8	33.2	12.8×10^{-2}	571	73.0
20	54.3	34.6	12.1×10^{-2}	1,196	145.0
21	56.5	35.7	11.8×10^{-2}	3,024	356.7
22	58.6	36.8	11.4×10^{-2}	6,120	697.4
23	60.8	37.8	11.0×10^{-2}	9,968	1,101.2
24	62.9	38.9	10.4×10^{-2}	11,180	1,168.1
25	65.1	40.0	10.1×10^{-2}	12,040	1,216.0
26	67.1	40.8	9.82×10^{-2}	10,136	995.5
27	69.0	41.6	9.56×10^{-2}	7,292	697.2
28	71.0	42.5	9.30×10^{-2}	5,902	549.0
29	72.9	43.3	9.04×10^{-2}	5,060	457.6
30	74.9	44.1	8.79×10^{-2}	4,476	393.4
31	76.7	44.6	8.62×10^{-2}	3,984	343.2
32	78.5	45.2	8.44×10^{-2}	3,566	301.1
33	80.2	45.7	8.28×10^{-2}	3,224	266.8
34	82.0	46.3	8.11×10^{-2}	2,914	236.2
35	83.8	46.8	7.93×10^{-2}	2,700	214.2
36	85.5	47.2	7.82×10^{-2}	2,448	191.4
37	87.2	47.5	7.71×10^{-2}	2,230	171.9
38	88.9	47.9	7.60×10^{-2}	2,074	157.6
39	90.6	48.2	7.48×10^{-2}	1,968	147.3
40	92.3	48.6	7.37×10^{-2}	1,850	136.3
41	93.9	48.9	7.28×10^{-2}	1,694	123.3
42	95.4	49.2	7.19×10^{-2}	1,582	113.8
43	97.0	49.4	7.10×10^{-2}	1,454	103.3
44	98.5	49.7	7.02×10^{-2}	1,348	94.6
45	100.1	50.0	6.93×10^{-2}	1,272	88.1
46	101.6	50.0	6.92×10^{-2}	1,192	82.4
47	103.1	50.1	6.90×10^{-2}	1,118	77.2
48	104.7	50.1	6.89×10^{-2}	1,042	71.8
49	106.2	50.2	6.88×10^{-2}	1,010	69.5
50	107.7	50.2	6.87×10^{-2}	962	66.0
51	109.1	50.1	6.91×10^{-2}	882	61.0
52	110.5	49.9	6.95×10^{-2}	850	59.1
53	111.8	49.8	7.00×10^{-2}	804	56.3
54	113.2	49.6	7.04×10^{-2}	774	54.5
55	114.6	49.5	7.08×10^{-2}	774	54.8
56	115.9	49.2	7.16×10^{-2}	774	55.5
57	117.2	49.0	7.25×10^{-2}	774	56.1

TABLE A.7 SHOT CHEROKEE, ROUND 4B, QE 65 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
14	25.3	41.4	96.2×10^{-3}	100	9.71
15	27.3	44.7	86.9×10^{-3}	336	28.91
16	29.2	47.5	77.2×10^{-3}	993	76.70
17	31.1	50.4	68.4×10^{-3}	2,878	196.9
18	32.9	53.1	59.6×10^{-3}	8,164	486.5
19	34.8	55.8	50.8×10^{-3}	7,316	372.0
20	36.7	58.6	44.6×10^{-3}	2,732	121.7
21	38.4	61.1	39.0×10^{-3}	1,692	65.9
22	40.2	63.6	33.7×10^{-3}	1,056	35.6
23	42.0	66.1	29.4×10^{-3}	818	24.0
24	43.7	68.6	25.2×10^{-3}	564	14.2
25	45.5	71.1	21.9×10^{-3}	483	10.6
26	47.2	73.4	19.1×10^{-3}	360	6.86
27	49.0	75.6	16.6×10^{-3}	322	5.35
28	50.7	77.9	14.6×10^{-3}	280	4.08
29	52.4	80.2	13.0×10^{-3}	280	3.65
30	54.1	82.4	11.3×10^{-3}	242	2.72
31	55.8	84.5	9.77×10^{-3}	242	2.36
32	57.5	86.6	8.76×10^{-3}	242	2.12
33	59.2	88.6	7.78×10^{-3}	204	1.59
34	60.9	90.7	6.90×10^{-3}	204	1.41
35	62.6	92.8	6.08×10^{-3}	168	1.03
36	64.3	94.7	5.45×10^{-3}	165	0.899
37	66.0	96.6	4.86×10^{-3}	123	0.600
38	67.7	98.5	4.34×10^{-3}	119	0.515
39	69.3	100.4	3.99×10^{-3}	119	0.474
40	71.0	102.2	3.54×10^{-3}	119	0.421
41	72.7	104.0	3.16×10^{-3}	119	0.375
42	74.4	105.7	2.89×10^{-3}	84	0.244
43	76.0	107.4	2.61×10^{-3}	81	0.211
44	77.7	109.1	2.34×10^{-3}	81	0.189
45	79.4	110.8	2.15×10^{-3}	81	0.174
46	81.0	112.4	1.97×10^{-3}	81	0.159
47	82.7	113.9	1.77×10^{-3}	81	0.143
48	84.4	115.5	1.64×10^{-3}	81	0.132
49	86.0	117.0	1.50×10^{-3}	81	0.121

TABLE A.8 SHOT CHEROKEE, ROUND 6B, QE 85 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
15	5.9	52.9	60.2×10^{-3}	83	4.99
16	6.3	56.4	49.8×10^{-3}	175	8.71
17	6.7	59.9	42.6×10^{-3}	288	12.3
18	7.2	63.4	33.9×10^{-3}	360	12.2
19	7.6	67.0	27.7×10^{-3}	366	10.2
20	8.0	70.5	22.5×10^{-3}	316	7.11
21	8.4	73.8	18.6×10^{-3}	275	5.12
22	8.8	77.0	15.4×10^{-3}	235	3.62
23	9.2	80.3	12.9×10^{-3}	195	2.52
24	9.6	83.5	10.4×10^{-3}	170	1.76
25	10.0	86.8	8.62×10^{-3}	139	1.20
26	10.4	89.9	7.28×10^{-3}	125	0.910
27	10.8	92.9	6.02×10^{-3}	112	0.673
28	11.2	96.0	5.04×10^{-3}	99	0.499
29	11.7	99.0	4.24×10^{-3}	86	0.364
30	12.1	102.1	3.59×10^{-3}	73	0.263
31	12.5	105.0	2.99×10^{-3}	61	0.182
32	12.9	107.8	2.54×10^{-3}	60	0.152
33	13.3	110.7	2.16×10^{-3}	58	0.125
34	13.7	113.6	1.81×10^{-3}	46	0.083
35	14.1	116.5	1.55×10^{-3}	44	0.068

TABLE A.9 SHOT ZUNI, ROUND 3A, QE 45 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration	Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3	sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
17	46.4	31.5	13.3×10^{-2}	115	15.3	55	115.3	53.1	5.94×10^{-2}	3,727	221.7
18	48.9	33.0	12.9×10^{-2}	569	73.4	56	116.7	52.9	6.01×10^{-2}	3,811	229.2
19	51.4	34.4	12.1×10^{-2}	2,534	308.2	57	118.1	52.7	6.08×10^{-2}	3,923	238.6
20	53.8	35.9	11.7×10^{-2}	4,768	559.9	58	119.4	52.5	6.15×10^{-2}	4,094	251.8
21	56.0	37.0	11.2×10^{-2}	6,449	727.8	59	120.8	52.2	6.21×10^{-2}	4,204	261.5
22	58.2	38.2	10.8×10^{-2}	6,525	710.8	60	122.2	52.0	6.28×10^{-2}	4,358	274.0
23	60.3	39.3	10.3×10^{-2}	7,165	738.5	61	123.5	51.7	6.39×10^{-2}	4,434	283.7
24	62.5	40.4	9.94×10^{-2}	6,824	679.0	62	124.8	51.3	6.50×10^{-2}	4,658	303.2
25	64.7	41.6	9.58×10^{-2}	6,320	605.6	63	126.2	51.0	6.62×10^{-2}	4,916	325.4
26	66.7	42.4	9.30×10^{-2}	6,468	601.9	64	127.5	50.6	6.73×10^{-2}	5,180	348.9
27	68.6	43.3	9.02×10^{-2}	6,304	469.2	65	128.8	50.2	6.84×10^{-2}	5,180	354.8
28	70.6	44.2	8.75×10^{-2}	6,099	534.1	66	130.0	49.7	7.00×10^{-2}	5,220	365.6
29	72.6	45.1	8.47×10^{-2}	5,472	463.9	67	131.3	49.3	7.15×10^{-2}	5,430	388.7
30	74.6	45.9	8.20×10^{-2}	4,787	392.9	68	132.5	48.8	7.31×10^{-2}	5,712	417.7
31	76.4	46.6	7.99×10^{-2}	4,336	346.8	69	133.7	48.3	7.47×10^{-2}	6,071	453.6
32	78.2	47.2	7.79×10^{-2}	4,200	327.2	70	135.0	47.8	7.62×10^{-2}	6,229	475.1
33	80.0	47.9	7.58×10^{-2}	4,176	316.9	71	136.1	47.2	7.81×10^{-2}	6,400	500.
34	81.9	48.6	7.38×10^{-2}	4,130	304.8	72	137.3	46.5	8.01×10^{-2}	6,459	517.7
35	83.7	49.2	7.17×10^{-2}	4,266	306.0	73	138.5	45.9	8.21×10^{-2}	7,041	578.2
36	85.4	49.7	7.03×10^{-2}	4,292	301.8	74	139.6	45.3	8.40×10^{-2}	7,532	633.0
37	87.1	50.1	6.88×10^{-2}	4,060	279.7	75	140.8	44.7	8.59×10^{-2}	7,830	673.3
38	88.8	50.6	6.74×10^{-2}	3,825	257.9	76	141.9	44.0	8.83×10^{-2}	7,915	699.1
39	90.5	51.0	6.59×10^{-2}	3,580	236.2	77	143.0	43.2	9.05×10^{-2}	7,858	711.8
40	92.2	51.5	6.45×10^{-2}	3,335	215.3	78	144.0	42.5	9.29×10^{-2}	7,728	717.9
41	93.9	51.8	6.37×10^{-2}	3,186	203.0	79	145.1	41.8	9.52×10^{-2}	7,500	714.1
42	95.5	52.0	6.28×10^{-2}	3,141	197.4	80	146.2	41.0	9.74×10^{-2}	7,200	701.8
43	97.1	52.3	6.19×10^{-2}	3,225	199.8	81	147.2	40.2	10.0×10^{-2}	6,460	647.8
44	98.7	52.6	6.10×10^{-2}	3,335	203.7	82	148.2	39.4	10.2×10^{-2}	5,000	514.2
45	100.3	52.9	6.02×10^{-2}	3,435	206.8	83	149.2	38.6	10.6×10^{-2}	2,750	293.2
46	101.9	53.0	5.98×10^{-2}	3,680	220.3	84	150.2	37.7	11.0×10^{-2}	1,640	181.7
47	103.4	53.1	5.95×10^{-2}	3,940	234.6	85	151.2	36.9	11.3×10^{-2}	1,030	116.8
48	104.9	53.2	5.92×10^{-2}	3,714	220.0	86	152.1	36.0	11.6×10^{-2}	657	76.8
49	106.5	53.3	5.89×10^{-2}	3,449	203.2	87	153.0	35.1	11.9×10^{-2}	452	54.1
50	108.0	53.4	5.85×10^{-2}	3,302	193.4	88	153.9	34.2	12.2×10^{-2}	265	32.5
51	109.5	53.3	5.87×10^{-2}	3,357	197.3	89	154.8	33.3	12.7×10^{-2}	172	21.9
52	110.9	53.3	5.89×10^{-2}	3,429	202.1	90	155.7	32.4	13.0×10^{-2}	96	12.7
53	112.4	53.2	5.91×10^{-2}	3,513	207.7	91	156.5	31.4	13.3×10^{-2}	49	6.57
54	113.8	53.2	5.93×10^{-2}	3,672	217.8	92	157.3	30.5	13.8×10^{-2}	41	5.67
						93	158.1	29.6	14.4×10^{-2}	41	5.93

TABLE A.10 SHOT ZUNI, ROUND 4A, QE 55 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration	Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3	sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
16	37.8	39.5	102.5×10^{-3}	149	15.4	40	86.9	78.0	14.5×10^{-3}	404	5.87
17	40.1	41.6	95.6×10^{-3}	450	43.1	41	88.8	79.0	13.9×10^{-3}	387	5.39
18	42.4	43.8	88.8×10^{-3}	1,120	99.5	42	90.6	80.0	13.2×10^{-3}	348	4.60
19	44.7	46.0	82.0×10^{-3}	2,200	180.6	43	92.5	81.0	12.3×10^{-3}	348	4.29
20	47.0	48.1	75.2×10^{-3}	4,615	347.3	44	94.3	82.0	11.7×10^{-3}	328	3.85
21	49.2	49.9	69.5×10^{-3}	8,300	576.7	45	96.2	83.0	10.7×10^{-3}	267	2.87
22	51.3	51.8	63.7×10^{-3}	11,600	738.9	46	98.0	83.8	10.2×10^{-3}	232	2.37
23	53.4	53.6	57.9×10^{-3}	12,740	737.8	47	99.9	84.6	9.69×10^{-3}	232	2.25
24	55.5	55.4	52.1×10^{-3}	11,063	576.7	48	101.7	85.4	9.30×10^{-3}	232	2.16
25	57.6	57.3	47.8×10^{-3}	8,030	384.3	49	103.6	86.3	8.96×10^{-3}	232	2.08
26	59.6	58.9	44.3×10^{-3}	5,115	226.5	50	105.4	87.1	8.47×10^{-3}	232	1.96
27	61.6	60.4	41.1×10^{-3}	3,380	139.0	51	107.2	87.8	8.26×10^{-3}	232	1.92
28	63.6	62.0	36.2×10^{-3}	2,545	93.0	52	109.0	88.4	7.92×10^{-3}	222	1.76
29	65.7	63.6	33.7×10^{-3}	1,965	66.2	53	110.9	89.1	7.54×10^{-3}	172	1.30
30	67.7	65.2	31.1×10^{-3}	1,560	48.5	54	112.9	89.7	7.32×10^{-3}	172	1.26
31	69.6	66.6	28.5×10^{-3}	1,258	35.9	55	114.5	90.4	7.06×10^{-3}	172	1.21
32	71.6	67.9	26.2×10^{-3}	1,054	27.6	56	116.3	90.9	6.82×10^{-3}	116	0.791
33	73.5	69.3	24.1×10^{-3}	914	22.0	57	118.1	91.4	6.65×10^{-3}	109	0.726
34	75.4	70.7	22.3×10^{-3}	786	17.5	58	119.9	91.9	6.50×10^{-3}	102	0.664
35	77.4	72.1	20.7×10^{-3}	706	14.6	59	121.7	92.4	6.29×10^{-3}	95	0.599
36	79.3	73.2	19.2×10^{-3}	614	11.8	60	123.5	92.8	6.05×10^{-3}	88	0.535
37	81.2	74.4	17.7×10^{-3}	556	9.8	61	125.3	93.2	5.92×10^{-3}	81	0.483
38	83.1	75.6	16.6×10^{-3}	500	8.32	62	127.1	93.5	5.82×10^{-3}	74	0.435
39	85.0	76.8	15.6×10^{-3}	446	6.97	63	128.9	93.8	5.72×10^{-3}	67	0.388
						64	130.6	94.2	5.62×10^{-3}	61	0.342

TABLE A.11 SHOT ZUNI, ROUND 5A, QE 65 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
16	29.2	47.5	77.2×10^{-3}	31	2.39
17	31.1	50.3	68.4×10^{-3}	185	12.6
18	32.9	53.1	59.6×10^{-3}	370	22.0
19	34.8	55.8	50.8×10^{-3}	586	29.8
20	36.6	58.6	44.6×10^{-3}	771	34.3
21	38.4	61.1	39.0×10^{-3}	804	31.3
22	40.2	63.6	33.6×10^{-3}	741	24.9
23	42.0	66.1	29.4×10^{-3}	710	20.8
24	43.7	68.6	25.2×10^{-3}	678	17.1
25	45.5	71.1	21.9×10^{-3}	647	14.1
26	47.2	73.4	19.0×10^{-3}	615	11.7
27	49.0	75.6	16.6×10^{-3}	588	9.77
28	50.7	77.9	14.6×10^{-3}	557	8.12
29	52.4	80.2	13.0×10^{-3}	540	7.04
30	54.1	82.4	11.3×10^{-3}	525	5.91
31	55.8	84.5	9.77×10^{-3}	494	4.83
32	57.5	86.6	8.76×10^{-3}	463	4.06
33	59.2	88.6	7.78×10^{-3}	448	3.48
34	60.9	90.7	6.90×10^{-3}	431	2.97
35	62.6	92.8	6.08×10^{-3}	415	2.52
36	64.3	94.7	5.45×10^{-3}	414	2.26
37	66.0	96.6	4.86×10^{-3}	382	1.85
38	67.7	98.5	4.33×10^{-3}	368	1.59
39	69.3	100.3	3.99×10^{-3}	360	1.43
40	71.0	102.2	3.54×10^{-3}	350	1.24
41	72.7	104.0	3.16×10^{-3}	338	1.07
42	74.4	105.7	2.89×10^{-3}	310	0.895
43	76.0	107.4	2.62×10^{-3}	291	0.761
44	77.7	109.1	2.34×10^{-3}	278	0.650
45	79.4	110.8	2.15×10^{-3}	260	0.558
46	81.0	112.4	1.97×10^{-3}	247	0.486
47	82.7	113.9	1.77×10^{-3}	228	0.403
48	84.4	115.5	1.64×10^{-3}	216	0.354
49	86.0	117.0	1.50×10^{-3}	209	0.314
50	87.7	118.6	1.35×10^{-3}	203	0.273

TABLE A.12 SHOT ZUNI, ROUND 2B, QE 45 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration	Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3	sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
13	35.6	24.8	16.8×10^{-2}	88	14.8	49	106.5	53.3	5.89×10^{-2}	4,172	245.8
14	38.5	26.7	15.9×10^{-2}	114	18.2	50	108.0	53.4	5.86×10^{-2}	3,798	222.5
15	41.5	28.6	15.0×10^{-2}	133	20.0	51	109.5	53.3	5.88×10^{-2}	3,660	215.1
16	44.9	30.1	14.1×10^{-2}	153	21.6	52	110.9	53.3	5.89×10^{-2}	3,265	192.4
17	46.4	31.5	13.3×10^{-2}	173	23.1	53	112.4	53.2	5.91×10^{-2}	2,922	172.8
18	48.9	33.0	12.9×10^{-2}	179	23.1	54	113.8	53.2	5.93×10^{-2}	2,652	157.3
19	51.4	34.4	12.2×10^{-2}	155	18.8	55	115.3	53.1	5.95×10^{-2}	2,487	147.9
20	53.8	35.9	11.7×10^{-2}	128	15.0	56	116.7	52.9	6.02×10^{-2}	2,461	148.0
21	56.0	37.0	11.3×10^{-2}	129	14.6	57	118.1	52.7	6.08×10^{-2}	2,482	151.9
22	58.2	38.2	10.9×10^{-2}	169	18.4	58	119.4	52.5	6.15×10^{-2}	2,610	160.5
23	60.3	39.3	10.3×10^{-2}	219	22.6	59	120.8	52.2	6.22×10^{-2}	2,813	175.0
24	62.5	40.4	9.95×10^{-2}	298	29.7	60	122.2	52.0	6.29×10^{-2}	3,050	191.7
25	64.7	41.6	9.58×10^{-2}	415	39.8	61	123.5	51.7	6.40×10^{-2}	3,260	208.6
26	66.7	42.4	9.31×10^{-2}	535	49.8	62	124.8	51.3	6.51×10^{-2}	3,380	220.0
27	68.6	43.3	9.03×10^{-2}	676	61.1	63	126.2	51.0	6.62×10^{-2}	3,460	229.1
28	70.6	44.2	8.76×10^{-2}	828	72.5	64	127.5	50.6	6.73×10^{-2}	3,580	241.1
29	72.6	45.1	8.48×10^{-2}	1,013	85.9	65	128.8	50.2	6.85×10^{-2}	3,780	258.9
30	74.6	45.9	8.21×10^{-2}	1,256	103.1	66	130.0	49.7	7.00×10^{-2}	3,860	270.4
31	76.4	46.6	8.00×10^{-2}	1,536	122.8	67	131.3	49.3	7.16×10^{-2}	3,820	273.4
32	78.2	47.2	7.79×10^{-2}	1,872	145.8	68	132.5	48.8	7.31×10^{-2}	3,820	279.4
33	80.0	47.9	7.59×10^{-2}	2,182	165.6	69	133.7	48.2	7.47×10^{-2}	3,780	282.4
34	81.9	48.6	7.38×10^{-2}	2,446	180.5	70	135.0	47.8	7.63×10^{-2}	3,700	282.2
35	83.7	49.2	7.17×10^{-2}	2,714	194.7	71	136.1	47.2	7.82×10^{-2}	3,500	273.7
36	85.4	49.7	7.03×10^{-2}	2,984	209.8	72	137.3	46.5	8.02×10^{-2}	3,218	257.9
37	87.1	50.1	6.89×10^{-2}	3,274	225.5	73	138.5	45.9	8.21×10^{-2}	2,929	240.5
38	88.8	50.6	6.74×10^{-2}	3,687	248.6	74	139.6	45.3	8.40×10^{-2}	2,612	219.5
39	90.5	51.0	6.60×10^{-2}	4,091	270.1	75	140.8	44.7	8.60×10^{-2}	2,373	204.1
40	92.2	51.5	6.46×10^{-2}	4,414	284.9	76	141.9	44.0	8.83×10^{-2}	2,161	190.9
41	93.9	51.8	6.37×10^{-2}	4,531	288.6	77	143.0	43.2	9.06×10^{-2}	1,969	178.4
42	95.5	52.0	6.28×10^{-2}	4,510	283.4	78	144.0	42.5	9.29×10^{-2}	1,698	157.7
43	97.1	52.3	6.20×10^{-2}	4,534	281.0	79	145.1	41.8	9.52×10^{-2}	1,490	141.9
44	98.7	52.6	6.11×10^{-2}	4,622	282.4	80	146.2	41.0	9.75×10^{-2}	1,150	112.2
45	100.3	52.9	6.02×10^{-2}	4,724	284.4	81	147.2	40.2	10.0×10^{-2}	822	82.5
46	101.9	53.0	5.99×10^{-2}	4,770	285.6	82	148.2	39.4	10.3×10^{-2}	598	61.5
47	103.4	53.1	5.96×10^{-2}	4,686	279.1	83	149.2	38.6	10.7×10^{-2}	456	48.6
48	104.9	53.2	5.92×10^{-2}	4,460	264.2						

TABLE A.13 SHOT ZUNI, ROUND 3B, QE 55 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration	Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3	sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
12	27.7	29.4	145.3×10^{-3}	105	15.3	56	116.3	90.9	6.82×10^{-3}	212	1.45
13	30.3	32.1	131.8×10^{-3}	168	22.2	57	118.1	91.4	6.65×10^{-3}	207	1.38
14	32.9	34.7	120.9×10^{-3}	238	28.8	58	119.9	91.9	6.50×10^{-3}	196	1.27
15	35.6	37.3	112.0×10^{-3}	375	42.0	59	121.7	92.4	6.29×10^{-3}	191	1.20
16	37.8	39.5	102.5×10^{-3}	504	51.7	60	123.5	92.8	6.05×10^{-3}	180	1.09
17	40.1	41.6	95.6×10^{-3}	606	58.0	61	125.3	93.2	5.92×10^{-3}	178	1.06
18	42.4	43.8	88.8×10^{-3}	659	58.6	62	127.1	93.5	5.82×10^{-3}	172	1.00
19	44.7	46.0	82.0×10^{-3}	845	69.3	63	128.9	93.8	5.72×10^{-3}	165	0.949
20	47.0	48.1	75.2×10^{-3}	1,130	85.0	64	130.6	94.2	5.62×10^{-3}	159	0.897
21	49.1	49.9	69.5×10^{-3}	1,402	97.4	65	132.4	94.5	5.51×10^{-3}	153	0.847
22	51.3	51.8	63.7×10^{-3}	1,760	112.1	66	134.2	94.6	5.46×10^{-3}	147	0.805
23	53.4	53.6	57.9×10^{-3}	2,237	129.5	67	136.0	94.8	5.41×10^{-3}	141	0.764
24	55.5	55.4	52.1×10^{-3}	2,670	139.2	68	137.8	95.0	5.36×10^{-3}	135	0.724
25	57.6	57.3	47.8×10^{-3}	3,178	152.1	69	139.5	95.1	5.31×10^{-3}	129	0.685
26	59.6	58.9	44.3×10^{-3}	3,482	154.2	70	141.3	95.3	5.26×10^{-3}	123	0.646
27	61.6	60.4	41.1×10^{-3}	3,666	150.7	71	143.0	95.3	5.25×10^{-3}	119	0.625
28	63.6	62.0	36.2×10^{-3}	3,745	135.4	72	144.8	95.3	5.25×10^{-3}	115	0.605
29	65.7	63.6	33.7×10^{-3}	3,575	120.4	73	146.6	95.3	5.25×10^{-3}	111	0.584
30	67.7	65.2	31.1×10^{-3}	2,870	89.3	74	148.3	95.3	5.25×10^{-3}	107	0.564
31	69.6	66.6	28.5×10^{-3}	1,930	55.0	75	150.1	95.3	5.25×10^{-3}	103	0.543
32	71.6	67.9	26.2×10^{-3}	1,450	38.0	76	151.8	95.2	5.30×10^{-3}	99	0.527
33	73.5	69.3	24.1×10^{-3}	1,215	29.3	77	153.6	95.0	5.35×10^{-3}	95	0.511
34	75.4	70.7	22.3×10^{-3}	1,005	22.4	78	155.3	94.8	5.40×10^{-3}	91	0.495
35	77.4	72.1	20.7×10^{-3}	859	17.8	79	157.1	94.7	5.45×10^{-3}	87	0.479
36	79.3	73.2	19.2×10^{-3}	756	14.5	80	158.8	94.5	5.50×10^{-3}	84	0.461
37	81.2	74.4	17.7×10^{-3}	684	12.2	81	160.6	94.2	5.60×10^{-3}	82	0.463
38	83.1	75.6	16.6×10^{-3}	618	10.3	82	162.3	93.9	5.70×10^{-3}	81	0.465
39	85.0	76.8	15.6×10^{-3}	551	8.61	83	164.0	93.6	5.80×10^{-3}	80	0.466
40	86.9	78.0	14.5×10^{-3}	515	7.49	84	165.8	93.3	5.90×10^{-3}	79	0.467
41	88.8	79.0	13.9×10^{-3}	480	6.68	85	167.5	92.9	6.00×10^{-3}	78	0.468
42	90.6	80.0	13.2×10^{-3}	444	5.88	86	169.2	92.5	6.23×10^{-3}	76	0.478
43	92.5	81.0	12.3×10^{-3}	409	5.05	87	170.9	92.0	6.46×10^{-3}	75	0.488
44	94.3	82.0	11.7×10^{-3}	381	4.47	88	172.6	91.5	6.61×10^{-3}	74	0.491
45	96.2	83.0	10.7×10^{-3}	366	3.93	89	174.4	91.0	6.75×10^{-3}	73	0.494
46	98.0	83.8	10.2×10^{-3}	350	3.58	90	176.1	90.6	6.97×10^{-3}	72	0.501
47	99.9	84.6	9.69×10^{-3}	328	3.19	91	177.8	89.9	7.26×10^{-3}	68	0.495
48	101.7	85.4	9.30×10^{-3}	310	2.89	92	179.5	89.3	7.46×10^{-3}	64	0.481
49	103.6	86.3	8.96×10^{-3}	293	2.62	93	181.2	88.7	7.76×10^{-3}	60	0.472
50	105.4	87.1	8.47×10^{-3}	283	2.40	94	182.9	88.0	8.15×10^{-3}	57	0.466
51	107.2	87.8	8.26×10^{-3}	274	2.27	95	184.6	87.4	8.37×10^{-3}	53	0.447
52	109.0	88.4	7.92×10^{-3}	253	2.01	96	186.3	86.6	8.72×10^{-3}	49	0.434
53	110.9	89.1	7.54×10^{-3}	248	1.87	97	188.0	85.9	9.17×10^{-3}	46	0.422
54	112.7	89.7	7.32×10^{-3}	237	1.74	98	189.6	85.1	9.42×10^{-3}	42	0.399
55	114.5	90.4	7.06×10^{-3}	212	1.50	99	191.3	84.3	9.91×10^{-3}	38	0.383
						100	193.0	83.5	10.39×10^{-3}	35	0.363

TABLE A.14 SHOT ZUNI, ROUND 4B, QE 65 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
11	19.1	31.7	132.8×10^{-3}	60	7.97
12	21.2	35.0	120.1×10^{-3}	208	25.0
13	23.2	38.2	108.7×10^{-3}	430	46.8
14	25.3	41.4	96.2×10^{-3}	761	73.2
15	27.3	44.7	86.0×10^{-3}	1,303	112.0
16	29.2	47.5	77.2×10^{-3}	2,187	168.8
17	31.1	50.3	68.4×10^{-3}	3,617	247.4
18	32.9	53.1	59.6×10^{-3}	4,604	274.4
19	34.8	55.8	50.8×10^{-3}	3,952	200.9
20	36.6	58.6	44.6×10^{-3}	2,215	98.7
21	38.4	61.1	39.0×10^{-3}	1,185	46.2
22	40.2	63.6	33.6×10^{-3}	785	26.4
23	42.0	66.1	29.4×10^{-3}	582	17.1
24	43.7	68.6	25.2×10^{-3}	471	11.8
25	45.5	71.1	21.9×10^{-3}	379	8.30
26	47.2	73.4	19.0×10^{-3}	314	5.99
27	49.0	75.6	16.6×10^{-3}	274	4.56
28	50.7	77.9	14.6×10^{-3}	235	3.43
29	52.4	80.2	13.0×10^{-3}	201	2.63
30	54.1	82.4	11.3×10^{-3}	183	2.06
31	55.8	84.5	9.77×10^{-3}	167	1.64
32	57.5	86.6	8.76×10^{-3}	147	1.29
33	59.2	88.6	7.78×10^{-3}	127	0.992
34	60.9	90.7	6.90×10^{-3}	120	0.828
35	62.6	92.8	6.08×10^{-3}	120	0.729
36	64.3	94.7	5.45×10^{-3}	120	0.654
37	66.0	96.6	4.86×10^{-3}	120	0.582
38	67.7	98.5	4.34×10^{-3}	109	0.474
39	69.3	100.3	3.99×10^{-3}	99	0.394
40	71.0	102.2	3.54×10^{-3}	89	0.317
41	72.7	104.0	3.16×10^{-3}	80	0.252
42	74.4	105.7	2.89×10^{-3}	80	0.231
43	76.0	107.4	2.62×10^{-3}	80	0.209
44	77.7	109.1	2.34×10^{-3}	80	0.187
45	79.4	110.8	2.15×10^{-3}	80	0.171
46	81.0	112.4	1.97×10^{-3}	80	0.157
47	82.7	113.9	1.77×10^{-3}	80	0.141
48	84.4	115.5	1.64×10^{-3}	80	0.131
49	86.0	117.0	1.50×10^{-3}	80	0.120
50	87.7	118.6	1.35×10^{-3}	80	0.107

TABLE A.15 SHOT NAVAJO, ROUNDS 1A AND 2A, QE 35 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
Round 1A					
24	64.9	25.4	165.9×10^{-3}	56	9.29
Round 2A					
22	61.0	24.4	170.9×10^{-3}	74	12.6
23	63.0	24.9	167.8×10^{-3}	46	7.85
24	64.9	25.4	165.9×10^{-3}	46	7.67
25	66.9	25.9	164.4×10^{-3}	45	7.52
26	68.6	26.2	162.8×10^{-3}	45	7.36
27	70.3	26.4	160.9×10^{-3}	44	7.18
28	71.9	26.7	158.9×10^{-3}	44	7.01
29	73.6	27.0	157.0×10^{-3}	43	6.84
30	75.3	27.3	156.1×10^{-3}	43	6.72
31	76.7	27.4	155.8×10^{-3}	42	6.68
32	78.2	27.5	155.6×10^{-3}	42	6.53
33	79.6	27.6	155.3×10^{-3}	51	7.92
34	81.0	27.7	155.0×10^{-3}	68	10.54
35	82.5	27.8	154.7×10^{-3}	76	11.76
36	83.7	27.7	154.9×10^{-3}	55	8.52
37	84.9	27.6	155.1×10^{-3}	42	6.51

TABLE A.16 SHOT NAVAJO ROUND 1B, QE 55 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration	Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3	sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
19	44.7	46.0	82.0×10^{-3}	59	4.84	61	125.3	93.2	5.92×10^{-3}	174	1.03
20	47.0	48.1	75.2×10^{-3}	119	8.96	62	127.1	93.5	5.82×10^{-3}	170	0.990
21	49.2	49.9	69.5×10^{-3}	199	13.8	63	128.9	93.8	5.72×10^{-3}	166	0.949
22	51.3	51.8	63.7×10^{-3}	297	18.9	64	130.6	94.2	5.62×10^{-3}	162	0.910
23	53.4	53.6	57.9×10^{-3}	396	22.9	65	132.4	94.5	5.52×10^{-3}	158	0.871
24	55.5	55.4	52.1×10^{-3}	555	28.9	66	134.2	94.6	5.46×10^{-3}	158	0.863
25	57.6	57.3	47.8×10^{-3}	730	34.9	67	136.0	94.8	5.41×10^{-3}	158	0.854
26	59.6	58.9	44.3×10^{-3}	853	37.8	68	137.8	95.0	5.36×10^{-3}	158	0.846
27	61.6	60.4	41.1×10^{-3}	1,010	41.5	69	139.5	95.1	5.31×10^{-3}	158	0.838
28	63.6	62.0	36.2×10^{-3}	1,180	42.6	70	141.3	95.3	5.26×10^{-3}	158	0.830
29	65.7	63.6	33.7×10^{-3}	1,270	42.8	71	143.0	95.3	5.25×10^{-3}	158	0.830
30	67.7	65.2	31.1×10^{-3}	1,410	43.9	72	144.8	95.3	5.25×10^{-3}	158	0.830
31	69.6	66.6	28.5×10^{-3}	1,580	45.0	73	146.6	95.3	5.25×10^{-3}	158	0.829
32	71.6	67.9	26.2×10^{-3}	1,720	45.0	74	148.3	95.3	5.25×10^{-3}	158	0.829
33	73.5	69.3	24.1×10^{-3}	1,820	43.8	75	150.1	95.3	5.25×10^{-3}	158	0.829
34	75.4	70.7	22.3×10^{-3}	1,780	39.7	76	151.8	95.2	5.30×10^{-3}	158	0.837
35	77.4	72.1	20.7×10^{-3}	1,720	35.6	77	153.6	95.0	5.35×10^{-3}	158	0.845
36	79.3	73.2	19.2×10^{-3}	1,590	30.5	78	155.3	94.8	5.40×10^{-3}	158	0.853
37	81.2	74.4	17.7×10^{-3}	1,450	25.7	79	157.1	94.7	5.45×10^{-3}	158	0.861
38	83.1	75.6	16.6×10^{-3}	1,290	21.5	80	158.8	94.5	5.50×10^{-3}	158	0.868
39	85.0	76.8	15.6×10^{-3}	1,190	18.6	81	160.6	94.2	5.60×10^{-3}	162	0.907
40	86.9	78.0	14.5×10^{-3}	1,010	14.7	82	162.3	93.9	5.70×10^{-3}	166	0.946
41	88.8	79.0	13.9×10^{-3}	930	12.9	83	164.0	93.6	5.80×10^{-3}	170	0.985
42	90.6	80.0	13.2×10^{-3}	832	11.0	84	165.8	93.3	5.90×10^{-3}	174	1.036
43	92.5	81.0	12.3×10^{-3}	730	9.00	85	167.5	92.9	6.09×10^{-3}	178	1.078
44	94.3	82.0	11.7×10^{-3}	620	7.26	86	169.2	92.5	6.23×10^{-3}	190	1.184
45	96.2	83.0	10.7×10^{-3}	574	6.16	87	170.9	92.0	6.46×10^{-3}	202	1.304
46	98.0	83.8	10.2×10^{-3}	493	5.03	88	172.6	91.5	6.61×10^{-3}	214	1.413
47	99.9	84.6	9.69×10^{-3}	469	4.55	89	174.4	91.0	6.75×10^{-3}	226	1.536
48	101.7	85.4	9.30×10^{-3}	416	3.87	90	176.1	90.6	6.97×10^{-3}	238	1.668
49	103.6	86.3	8.96×10^{-3}	396	3.55	91	177.8	89.9	7.26×10^{-3}	226	1.649
50	105.4	87.1	8.47×10^{-3}	376	3.18	92	179.5	89.3	7.46×10^{-3}	214	1.606
51	107.2	87.8	8.26×10^{-3}	356	2.94	93	181.2	88.7	7.76×10^{-3}	202	1.576
52	109.0	88.4	7.92×10^{-3}	336	2.67	94	182.9	88.0	8.15×10^{-3}	190	1.559
53	110.9	89.1	7.54×10^{-3}	316	2.38	95	184.6	87.4	8.37×10^{-3}	178	1.499
54	112.7	89.7	7.32×10^{-3}	296	2.17	96	186.3	86.6	8.72×10^{-3}	208	1.814
55	114.5	90.4	7.06×10^{-3}	277	1.95	97	188.0	85.9	9.17×10^{-3}	238	2.183
56	116.3	90.9	6.82×10^{-3}	257	1.76	98	189.6	85.1	9.42×10^{-3}	198	1.879
57	118.1	91.4	6.65×10^{-3}	237	1.58	99	191.3	84.3	9.91×10^{-3}	158	1.571
58	119.9	91.9	6.50×10^{-3}	217	1.41	100	193.0	83.5	10.4×10^{-3}	119	1.246
59	121.7	92.4	6.29×10^{-3}	197	1.24	101	194.7	82.6	11.1×10^{-3}	59	0.656
60	123.5	92.8	6.05×10^{-3}	176	1.08						

TABLE A.17 SHOT NAVAJO, ROUND 2B, QE 65 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
12	21.2	35.0	120.1×10^{-3}	21	2.62
13	23.2	38.2	108.7×10^{-3}	59	6.51
14	25.3	41.4	96.2×10^{-3}	104	10.0
15	27.3	44.7	86.0×10^{-3}	208	17.9
16	29.2	47.6	77.2×10^{-3}	378	29.2
17	31.1	50.3	68.4×10^{-3}	651	44.6
18	32.9	53.1	59.6×10^{-3}	727	43.3
19	34.8	55.8	50.8×10^{-3}	702	35.7
20	36.6	58.6	44.6×10^{-3}	576	25.7
21	38.4	61.1	39.0×10^{-3}	343	13.4
22	40.2	63.6	33.6×10^{-3}	270	9.10
23	42.0	66.1	29.4×10^{-3}	264	7.76
24	43.7	68.6	25.2×10^{-3}	254	6.42
25	45.5	71.1	21.9×10^{-3}	234	5.13
26	47.2	73.4	19.0×10^{-3}	219	4.19
27	49.0	75.6	16.6×10^{-3}	199	3.31
28	50.7	77.9	14.6×10^{-3}	182	2.66
29	52.4	80.2	13.0×10^{-3}	163	2.14
30	54.1	82.4	11.3×10^{-3}	142	1.60
31	55.8	84.5	9.77×10^{-3}	125	1.23
32	57.5	86.6	8.76×10^{-3}	112	0.986
33	59.2	88.6	7.78×10^{-3}	108	0.840
34	60.9	90.7	6.90×10^{-3}	98	0.678
35	62.6	92.8	6.08×10^{-3}	90	0.550
36	64.3	94.7	5.45×10^{-3}	77	0.423
37	66.0	96.6	4.86×10^{-3}	73	0.357
38	67.7	98.5	4.34×10^{-3}	70	0.303
39	69.3	100.4	3.99×10^{-3}	70	0.279
40	71.0	102.2	3.54×10^{-3}	69	0.244
41	72.7	104.0	3.16×10^{-3}	59	0.188
42	74.4	105.7	2.89×10^{-3}	55	0.160
43	76.0	107.4	2.62×10^{-3}	53	0.138
44	77.7	109.1	2.34×10^{-3}	53	0.124
45	79.4	110.8	2.15×10^{-3}	53	0.113
46	81.0	112.4	1.97×10^{-3}	52	0.103
47	82.7	113.9	1.77×10^{-3}	49	0.087
48	84.4	115.5	1.64×10^{-3}	43	0.070
49	86.0	117.0	1.50×10^{-3}	42	0.064
50	87.7	118.6	1.35×10^{-3}	39	0.052
51	89.4	120.0	1.26×10^{-3}	38	0.048

TABLE A.18 SHOT NAVAJO, ROUND 5B, QE 65 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
12	21.2	35.0	120.1×10^{-3}	9	1.19
13	23.2	38.2	108.7×10^{-3}	38	4.23
14	25.3	41.4	96.2×10^{-3}	69	6.69
15	27.3	44.7	86.0×10^{-3}	121	10.4
16	29.2	47.5	77.2×10^{-3}	229	17.7
17	31.1	50.3	68.4×10^{-3}	408	28.0
18	32.9	53.1	59.6×10^{-3}	619	36.9
19	34.8	55.8	50.8×10^{-3}	741	37.7
20	36.6	58.6	44.6×10^{-3}	699	31.2
21	38.4	61.1	39.0×10^{-3}	624	24.3
22	40.2	63.6	33.6×10^{-3}	402	13.5
23	42.0	66.1	29.4×10^{-3}	300	8.82
24	43.7	68.6	25.2×10^{-3}	256	6.45
25	45.5	71.1	21.9×10^{-3}	229	5.02
26	47.2	73.4	19.1×10^{-3}	224	4.27
27	49.0	75.6	16.6×10^{-3}	215	3.58
28	50.7	77.9	14.6×10^{-3}	211	3.08
29	52.4	80.2	13.0×10^{-3}	203	2.65
30	54.1	82.4	11.3×10^{-3}	186	2.10
31	55.8	84.5	9.77×10^{-3}	176	1.72
32	57.5	86.6	8.76×10^{-3}	150	1.32
33	59.2	88.6	7.78×10^{-3}	146	1.14
34	60.9	90.7	6.90×10^{-3}	132	0.913
35	62.6	92.8	6.08×10^{-3}	125	0.760
36	64.3	94.7	5.45×10^{-3}	115	0.631
37	66.0	96.6	4.86×10^{-3}	104	0.506
38	67.7	98.5	4.34×10^{-3}	96	0.417
39	69.3	100.4	3.99×10^{-3}	89	0.346
40	71.0	102.2	3.54×10^{-3}	83	0.294
41	72.7	104.0	3.16×10^{-3}	82	0.259
42	74.4	105.7	2.89×10^{-3}	78	0.219
43	76.0	107.4	2.62×10^{-3}	75	0.198
44	77.7	109.1	2.34×10^{-3}	72	0.169

TABLE A.19 SHOT NAVAJO ROUND 6B, QE 85 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
13	5.0	45.0	85.0×10^{-3}	30	2.55
14	5.4	48.9	72.6×10^{-3}	174	12.6
15	5.9	52.9	60.2×10^{-3}	392	23.6
16	6.3	56.4	49.8×10^{-3}	313	15.6
17	6.7	59.9	42.6×10^{-3}	204	8.69
18	7.1	63.5	33.9×10^{-3}	189	6.41
19	7.6	67.0	27.7×10^{-3}	91	2.52
20	8.0	70.5	22.5×10^{-3}	68	1.53
21	8.4	73.8	18.6×10^{-3}	38	0.70

TABLE A.20 SHOT TEWA ROUND 3, QE 75 DEGREES

Time	Range	Altitude	Factor	Reading	Concentration
sec	10^3 ft	10^3 ft	$(mc/m^3)/(r/hr)$	r/hr	mc/m^3
12	13.3	39.0	104.3×10^{-3}	8	0.796
13	14.6	42.6	92.4×10^{-3}	21	1.99
14	15.9	46.4	80.8×10^{-3}	79	6.42
15	17.2	50.0	69.1×10^{-3}	245	16.9
16	18.4	53.3	58.8×10^{-3}	539	31.7
17	19.6	56.6	49.4×10^{-3}	1,029	50.9
18	20.9	59.8	42.7×10^{-3}	1,720	73.5
19	22.1	63.1	34.4×10^{-3}	2,400	82.6
20	23.3	66.4	28.8×10^{-3}	2,768	79.9
21	24.5	69.4	24.0×10^{-3}	2,746	65.8
22	25.6	72.4	20.3×10^{-3}	2,459	49.9
23	26.8	75.4	16.7×10^{-3}	2,143	36.0
24	28.0	78.4	14.3×10^{-3}	1,860	26.6
25	29.2	81.4	12.1×10^{-3}	1,616	19.5
26	30.3	84.1	10.0×10^{-3}	1,448	14.5
27	31.5	86.9	8.55×10^{-3}	1,298	11.1
28	32.6	89.7	7.33×10^{-3}	1,182	8.67
29	33.8	92.5	6.22×10^{-3}	1,043	6.49
30	34.9	95.3	5.27×10^{-3}	913	4.81
31	36.1	97.9	4.45×10^{-3}	808	3.60
32	37.2	100.5	3.95×10^{-3}	742	2.93
33	38.4	103.1	3.30×10^{-3}	663	2.19
34	39.5	105.6	2.89×10^{-3}	628	1.82
35	40.6	108.2	2.48×10^{-3}	563	1.40
36	41.8	110.7	2.16×10^{-3}	508	1.10
37	42.9	113.1	1.88×10^{-3}	483	0.907
38	44.0	115.5	1.64×10^{-3}	427	0.699
39	45.2	118.0	1.40×10^{-3}	408	0.569